STATE OF NEW YORK
CONSERVATION DEPARTMENT
WATER RESOURCES COMMISSION

TIME-OF-TRAVEL STUDY
MOHAWK RIVER

ROME, NEW YORK TO COHOES, NEW YORK

By
HAROLD L. SHINDEL
U.S. GEOLOGICAL SURVEY

REPORT OF INVESTIGATION
RI-6

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Prepared by
UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

in cooperation with
NEW YORK STATE HEALTH DEPARTMENT

STATE OF NEW YORK
CONSERVATION DEPARTMENT
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SUMMARY

Time of travel of water was determined for the 119.1-mile reach of the Mohawk River between Guard Gate No. 6 near Rome, New York, and the Crescent Dam near Cohoes, New York. A 40-percent solution of Rhodamine B dye was used to trace the time of travel of water during a low-flow period (summer 1966) and during a period of high flow (spring 1967). Because discharge is regulated by the operation of the Erie Barge Canal, there is no appreciable period of median flow on the canalized two-thirds of the study reach. The cumulative time of travel for all the subreaches of the study was 840 hours during low flows and 210 hours during high flows. Graphs are presented which show magnitude and frequency of discharge and the relationship between time of travel and discharge through the subreaches.

In addition to discharge, time of travel is also controlled by the shape and use of the channel section. On the basis of shape and use, each of the subreaches was classified into one of three types of channel sections: (1) the natural river section, (2) the river-canal section, or (3) the power-pool section. The natural river sections include 39.1 miles of the study reach and are characterized by relatively shallow cross sections and winding channels. The traveltime of water is least through these sections and does not follow the same extreme fluctuations between high and low flow that are prevalent in the other types of sections.

In the 58.9 miles of river-canal sections, the river channel has been straightened and dredged to accommodate canal traffic. These sections have thus become a series of pools separated by canal locks and dams. Time of travel through the pools is controlled by the two distinct periods of high and low flow that occur during the canal operating season: (1) during high flow the dam gates are opened more often and the time of travel is faster, and (2) during low flow the gates are closed more often and the time of travel is slower.

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The last 21.1 miles of the study reach consists of power-pool sections. These sections are the same as river-canal sections except that the operations of the hydroelectric powerplants produces the major influence on the time of travel. Flow through the power-pool sections is controlled by the amount of water available, by the capacity of the channel to act as a reservoir and to pond water, and by the schedule of power production. During low flow, water is ponded and saved for peak production hours causing the slowest time of travel in the study reach. During high flow, power is produced constantly and excess water passes through the section without entering the powerplants, thereby allowing a faster time of travel.

INTRODUCTION

The streams of New York carry and dilute large quantities of municipal and industrial effluents. This report presents the results of a study of the speed at which a pollutant might travel on the Mohawk River between Rome and Cohoes.

The report covers time-of-travel investigations made on the Mohawk River during the period June 1966 to August 1967 by the U.S. Geological Survey, Garald G. Parker, District Chief, in cooperation with the New York State Department of Health, Hollis S. Ingraham, M.D., Commissioner. Field assistance was provided by the New York State Department of Transportation, J. Burch McMorran, Commissioner.

The time needed by a stream to move water and its accompanying pollutants from point to point is called the time of travel between those points. Time of travel may be measured by using floats, by analyzing average stream velocities at selected cross sections, and by tracking various chemicals. The method used in this report is a recently developed variation of the chemical tracking method that employs fluorescent-dye tracers and seems to provide the most reliable results. Briefly stated, the method requires that a fluorescent dye be dumped into a stream and periodic samples then be taken at some downstream point until the slug of dye has passed. The time necessary for the peak concentration of the dye to pass from the dump point to the sample point is the time of travel between those points. The fluorescent-dye method is explained more fully in the "Procedures" section of the report.

Description of the Mohawk Basin

As shown in figure 1, the headwaters of the Mohawk River lie in the region of West Leyden, New York, about 20 miles north of Rome, New York. From the headwaters the river flows south through the Delta Reservoir until it joins the Erie Barge Canal near Rome and begins its easterly flow. The study reach and the sampling sites are shown in greater detail in figure 2.

The Mohawk River drains a total of about 3,460 square miles. Flow enters the Mohawk basin from the Black River basin through the Black River Canal and the Lansing Kill, which joins the Mohawk River near Hillside. Flow also enters the Mohawk basin from the Chenango River through Oriskany Creek feeder. There is flow into and out of the Mohawk basin from the Oswego River basin, but the main diversion of water is from Schoharie Creek through the Shandaken Tunnel for part of the New York City water supply.

Description of Discharge

The operation of the Erie Barge Canal is the major control of discharge. The canal season generally extends from April 1 to November 30. In the sections above Vischer Ferry and Crescent Dam, power production, consistent with maintaining canal levels, is the major controlling factor.

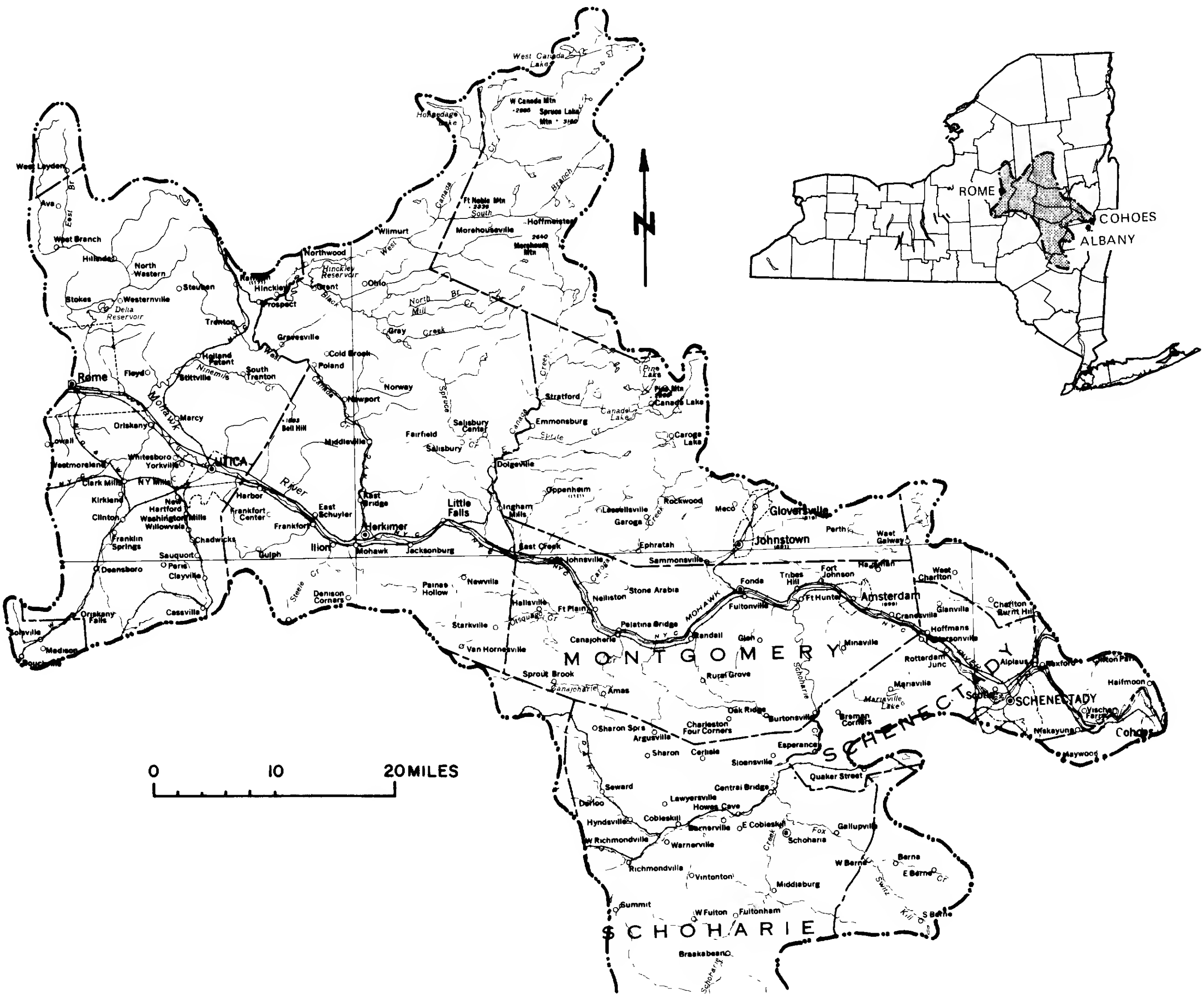

Figure 1.--Study reach and location of the Mohawk River basin.

The flow of the Mohawk River is gaged at three points. In downstream order, the first is the Mohawk River below Delta Dam near Rome; the second is the Mohawk River near Little Falls, 1,800 feet downstream from Fivemile Dam; and the third is the Mohawk River at Cohoes at the Niagara-Mohawk Corporation's School Street Powerplant, about 1 3/4 miles above where the Mohawk River joins the Hudson River. There are also seven gages on tributaries to the Mohawk. Table 1 lists the gages in downstream order, their drainage area, average flows, and means of regulation.

The flow-duration curve is an excellent means of showing distribution of flows by their frequency of occurrence. The curve is a plot of flow against the percentage of time that the flow was equaled or exceeded. A 90-percent flow is a low flow, one that is equaled or exceeded 90 percent of the time. Conversely, 10-percent flow indicates a high flow, one that is equaled or exceeded only 10 percent of the time. In pollution studies,

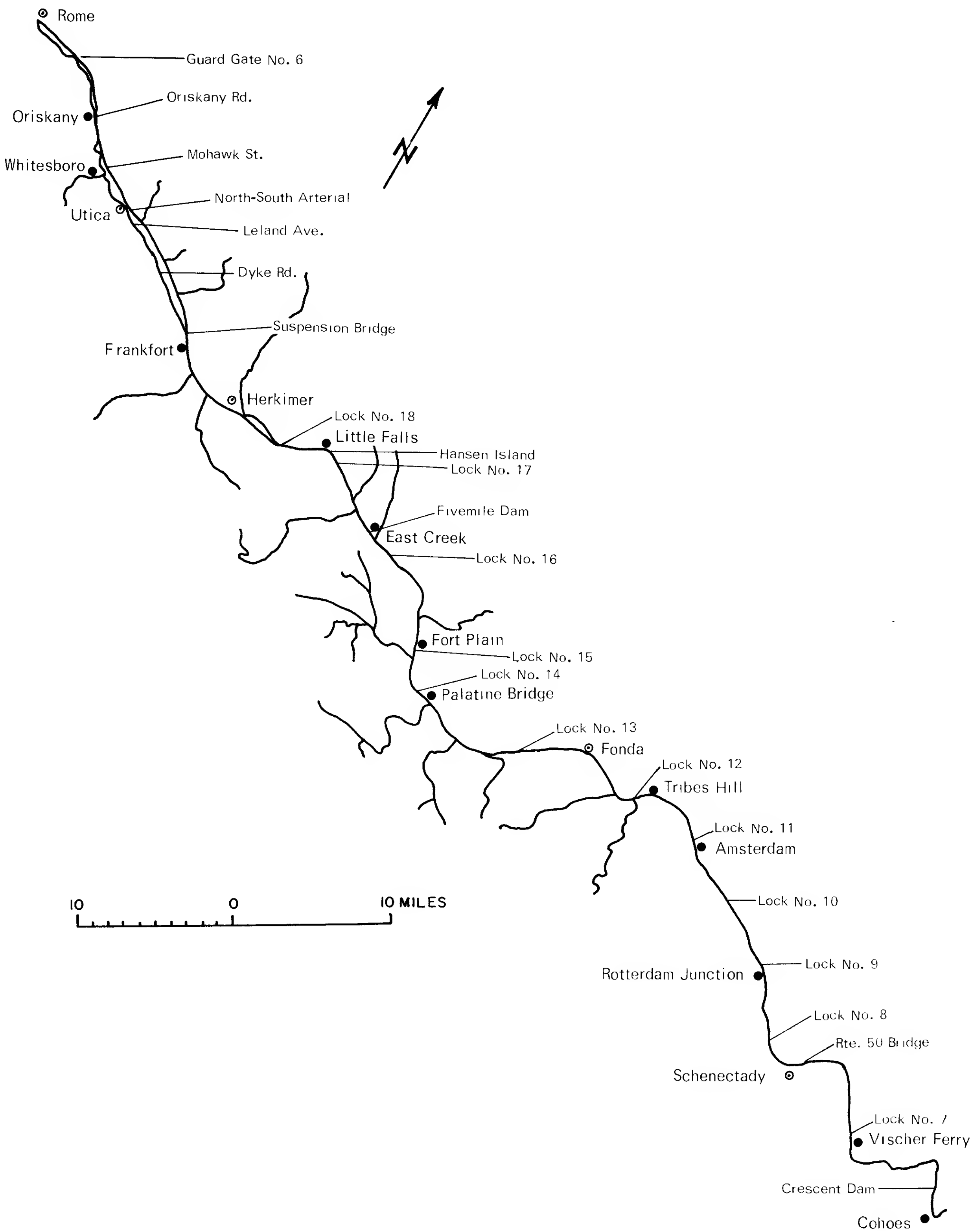

Figure 2.--Location of subreaches and sampling points.

the low-flow periods are the ones of interest because during these periods the stream has less water to ameliorate the effects of pollution. Generally, a 75-percent or higher duration indicates the low-flow regime. In the study reach, the gaging station near Little Falls was used as the principal index of flow in conducting the dye studies. Figure 3 shows the flow-duration curve for this gage. The high-flow dye studies were conducted when the discharge at the Little Falls gage had a duration of approximately 30 percent. During the low-flow dye studies, the duration of flow ranged from 70 to 99 percent. The 99-percent duration flow occurred only during very short periods and was the result of upstream regulation.

Table 1.--Gaging stations, indicating drainage area, average flow, and regulation, on the Mohawk River and tributary streams

Station	Drainage area (sq mi)	Average flow (cfs)	Regulation
Mohawk River below Delta Dam near Rome	150	[a] 375	Delta Reservoir
Ninemile Feeder	--	--	Canal season only
West Canada Creek at Kast Bridge	556	[a] 1,285	Hinkley Reservoir
Mohawk River near Little Falls	1,348	2,685	--
East Canada Creek at East Creek	291	642	Niagara Mohawk Hydro Plant
Otsquago Creek at Fort Plain	59.2	77.8	--
Schoharie Creek at Prattsville	236	449	--
Fox Creek at West Berne	73.0	95.2	--
Schoharie Creek at Burtonsville	883	--	Schoharie Reservoir (flow at Gilboa diverted to New York City)
Mohawk River at Cohoes	3,460	[a] 5,600	Niagara Mohawk Hydro Plant

[a] Unadjusted mean

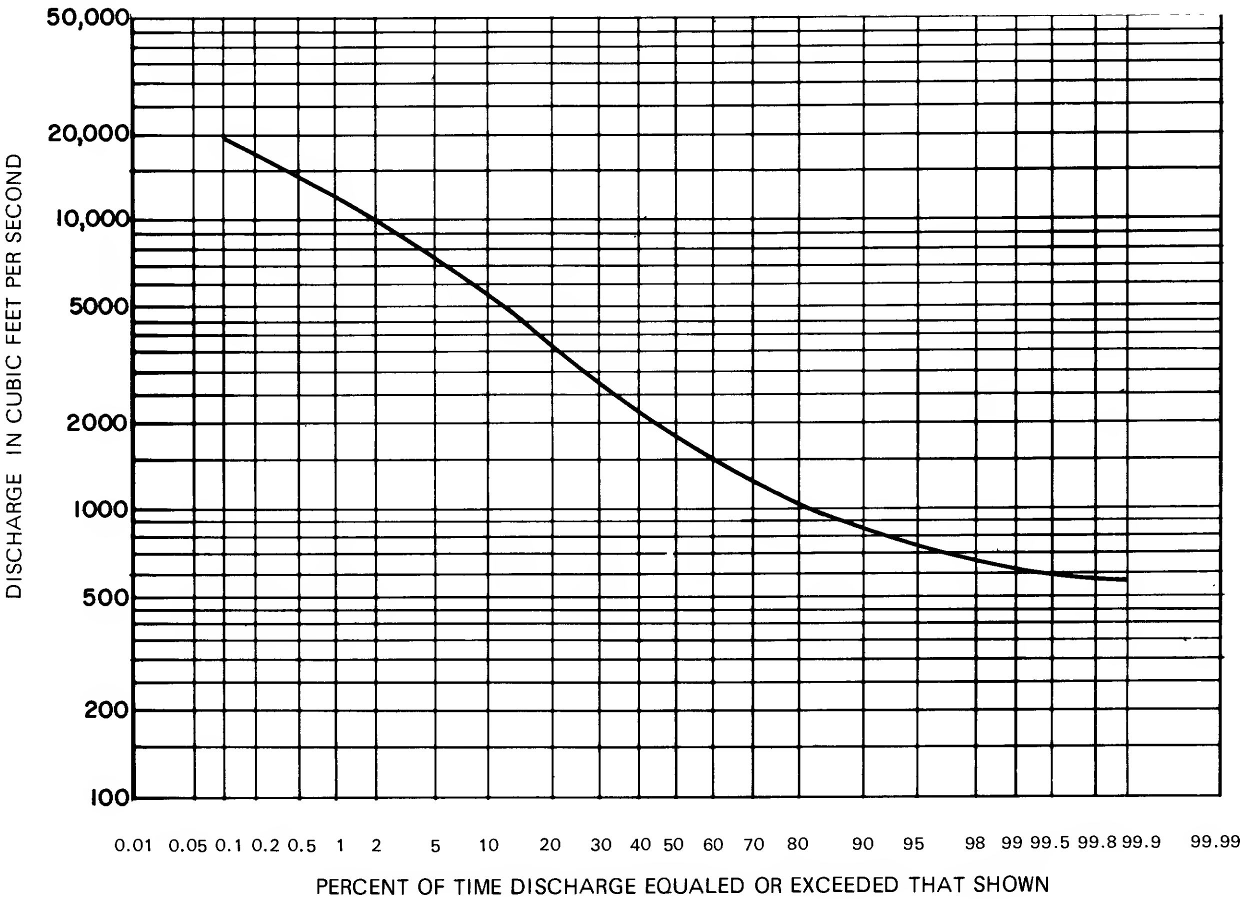

Figure 3.--Flow-duration curve of the Mohawk River near Little Falls.

PROCEDURES

Prior to actual field operations, field and map reconnaissance was conducted to determine the prospective subreaches, length of subreaches, and division of responsibility for sampling. Length of subreach was determined from the largest scale U.S.G.S. map available. Table 2 lists each subreach and its length, and figure 2 shows the location.

The field procedure consisted of injecting the dye at the upstream site and taking samples at scheduled times at the downstream sampling site. Although there are many dye tracers available for this type of study, a Rhodamine B 40-percent tracer was chosen. This tracer was chosen for its high detectability, economy, ease of handling and injection, and harmlessness in the concentrations used. Before injecting, it was necessary to compute the volume of dye to be injected so the peak concentration at the downstream site would be less than 10 ppb (parts per billion) in accordance with the U.S. Geological Survey policy. The amount of dye to be injected was computed by the formula:

$$Vd = CQT_e$$

where
- Vd is the amount of dye injected, in ounces
- Q is the discharge, in cubic feet per second
- T_e is the estimated time of travel, in hours
- C is a constant.

To assure a downstream concentration of less than 10 ppb a target concentration of 2 ppb was used. The final formula then became:

$$Vd_{(oz)} = 0.005\ Q_{(cfs)}\ T_{e(hrs)}$$

After the samples were taken, they were analyzed by fluorometer. The Turner Model III Fluorometer used to analyze the sample concentration is basically an optical bridge which, by the use of a rotating prism, relates the fluorescence of a sample to a calibrated rear light path. The machine is calibrated with prepared standards, the dial reading varying linearly at low concentrations with the amount of fluorescence. The machine may be used with either a flow-through door or with individual sample curvettes. An individual sampling technique was used in the study. The samples were analyzed in the lab and the concentration noted. The time interval between injection and arrival of the peak concentration of dye was considered the time of travel. Table 3 shows the amount of dye used, the peak concentrations observed, and the duration of the dye cloud.

The discharge was obtained from the streamflow records for the Mohawk River near Little Falls, West Canada Creek at Kast Bridge, and East Canada Creek at East Creek. Mean daily discharges for these stations are published in the U.S. Geological Survey basic-data report, "Water Resources Data for New York, Part 1. Surface Water Records." Table 4 gives an abstract of the description for these stations.

Streamflow measurements were made at several ungaged sites where flow data were needed. Table 5 lists the results of these measurements. Measurements of discharge were also obtained at the Vischer Ferry and Crescent power stations.

Table 2.--Study reaches showing channel type and length

Reach	Channel type	Mileage
Guard Gate #6 nr. Rome to Mohawk St., Whitesboro	River channel	10.3
Mohawk St., Whitesboro to Leland Ave., Utica	River channel mainly; toward Leland Ave., channel is deepened in order to form auxiliary canal for various Oil Co.	6.9
Leland Ave. Dam, Utica to Suspension Bridge, Frankfort	River channel with some large ponds	11.0
Frankfort to Herkimer	River-canal channel	4.8
Herkimer Guard Gate # 5 to Lock 18	River channel	4.6
Lock 18 to Hansen Island, Little Falls	River-canal channel	3.2
Hansen Island Little Falls to Lock 17	River channel	1.1
Lock 17 to Fivemile Dam	River-canal channel	3.8
Fivemile Dam to Lock 16	River channel	4.4
Lock 16 to Lock 15	River-canal channel	6.6
Lock 15 to Lock 14	do.	3.5
Lock 14 to Lock 13	do.	7.8
Lock 13 to Fonda	do.	4.6
Fonda to Lock 12	do.	5.1
Lock 12 to Lock 11	do.	4.3
Lock 11 to Lock 10	do.	4.3
Lock 10 to Lock 9	do.	6.0
Lock 9 to Lock 8	do.	4.9
Lock 8 to N.Y. Hwy. 50, Schenectady	Power pool; large overflow areas	4.1
N.Y. Hwy. 50, Schenectady to Lock 7, Vischers Ferry	do.	6.8
Vischers Ferry to Crescent Dam	do.	10.2

Table 3.--Use and dispersion of the dye in the Mohawk River

Reach	Date	Discharge (cfs)	Amount of dye (oz)b/	Peak concentration (ppb)c/	Duration of dye cloud (hrs)
Guard Gate 6 nr. Rome					
to Oriskany Rd., Oriskany	6/13/66	263	87	20.2	11.4
	5/30/67	221	96	a/16	a/10
	8/10/67	1,200	64	2.9	5.5
to Mohawk St., Whitesboro	6/14/66	372	87	7.6	7.6
	5/30/67	394	96	11.4	6.5
	8/10/67	1,380	64	2.0	6.0
Mohawk St., Whitesboro					
to North South Arterial, Utica	6/13/66	438	145	37.4	7.4
	8/ 8/67	491	48	a/10	5.5
to Leland Ave., Utica	6/15/66	695	56	11.9	4.5
	8/ 9/67	449	48	5.5	8.0
Leland Ave Dam, Utica					
to Dyke Road, Schuyler	6/15/66	705	257	31	6.6
	9/ 8/66	a/600	96	17.1	13.6
	8/15/67	a/600	64	6.0	9.5
to Suspension Bridge, Frankfort	6/16/66	758	257	19.5	8.0
	9/ 8/66	561	96	10.0	16.0
	8/15/67	580	64	3.8	14.0
Frankfort to Herkimer	6/26/66	879	272	4.4	28.5
	5/30/67	742	128	1.7	18
Herkimer Guard Gate #5 to Lock 18	6/20/66	1,360	48	7.6	7.5
	5/24/67	2,020	32	a/4.0	3.5
	8/17/67	980	48	4.5	6.5
Lock 18 to Hansen Island, Little Falls	6/23/66	1,140	208	4.0	18
	5/23/67	2,450	96	4.4	4.5
Hansen Island, Little Falls					
to Lock 17	6/22/66	1,310	448	70.8	7.5
	5/22/67	3,140	160	12.9	2.4
to Fivemile Dam	6/22/66	1,390	448	9.2	21.0
	5/22/67	3,460	160	4.2	7.5
Fivemile Dam to Lock 16	7/ 7/66	1,840	144	14.0	4.1
	10/11/66	2,000	48	10.8	3.0
	5/11/67	4,660	64	3.4	1.1
Lock 16 to Lock 15	7/11/66	1,200	480	3.7	a/57
	5/11/67	5,450	256	3.3	9.5
Lock 15 to Lock 14	7/11/66	1,200	480	3.7	a/ 57
	5/10/67	5,450	144	1.6	6.0
Lock 14 to Lock 13	7/12/66	1,200	708	3.8	140
	5/10/67	5,450	288	2.8	17.0
Lock 13 to Fonda	8/ 1/66	803	256	1.5	75
	5/10/67	a/8,000	240	2.6	3.5
Fonda to Lock 12	8/ 2/66	631	320	2.4	a/45
	5/ 8/67	7,020	256	a/5.0	3.0
Lock 12 to Lock 11	7/26/66	974	320	2.1	55
	5/ 9/67	10,000	216	2.6	12.0
Lock 11 to Lock 10	7/26/66	974	320	2.9	42
	5/ 9/67	10,000	216	.4	4.5
Lock 10 to Lock 9	7/25/66	968	640	2.7	50
	5/18/67	7,930	160	1.1	11.0
Lock 9 to Lock 8	7/25/66	968	576	3.4	96
	5/18/67	7,930	128	1.6	8.0
Lock 8					
to Rt. 50 Bridge, Schenectady	7/18/66	a/1,500	1,536	17.8	32
	5/ 8/67	7,250	1,024	4.6	5.0
to Vischers Ferry	7/20/66	a/940	1,536	4.2	147
	5/ 8/67	7,250	1,024	--	a/20
Vischers Ferry to Crescent Dam	7/18/66	a/1,000	2,304	1.3	160+
	5/ 8/67	8,060	1,024	1.4	22.0

a/ - about.
b/ - to compute amount of dye injected in milliliters, multiply by 29.57.
c/ - same as micrograms per liter.

Table 4.--Gaging station descriptions

1-3460. West Canada Creek at Kast Bridge, N. Y.

Location.--Lat 43°04'15", long 74°59'25", on left bank 600 feet downstream from bridge on State Highway 28 at Kast Bridge Station on New York Central Railroad, Herkimer County, 4 miles upstream from mouth near Herkimer.

Drainage area.--556 sq mi.

Gage.--Water-stage recorder (digital). Datum of gage is 438.99 ft above mean sea level.

Remarks.--Flow partly regulated by Hinckley Reservoir, 31 miles above station. Diurnal fluctuation at low and median flow caused by power plants above station. Diversion at Trenton Falls, 26 miles above station by Ninemile feeder during canal navigation season. Diversion from Hinckley Reservoir for Utica water supply returned to Mohawk River.

1-3470. Mohawk River near Little Falls, N. Y.

Location.--Lat 43°00'50", long 74°46'40", on left bank 1,800 feet downstream from Rocky Rift (Fivemile) Dam, 2 miles upstream from East Canada Creek.

Drainage area.--1,348 sq mi.

Gage.--Water-stage recorder (digital). Datum of gage is 310.0 ft above mean sea level (Barge Canal datum).

Remarks.--During canal navigation season, water is received from Black River basin through Black River Canal flowing south, and Lansing Kill, and from Chenango River basin through Oriskany Creek feeder. Water is diverted into (or may occasionally be received from) Oswego River basin through summit level of Erie (Barge) Canal between New London and Utica. Diurnal fluctuation caused by power plants and locks and dams on Erie (Barge) Canal. Appreciable regulation by Delta and Hinckley Reservoirs (combined usable capacity 6,120,000,000 cu ft).

1-3480. East Canada Creek at East Creek, N. Y.

Location.--Lat 43°01'00", long 74°44'30", on right bank at village of East Creek, Herkimer County, a quarter of a mile downstream from Niagara Mohawk Power Corp. Beardslee power plant, 1 1/4 miles upstream from mouth.

Drainage area.--291 sq mi.

Gage.--Water-stage recorder (digital). Datum of gage is 335.70 ft above mean sea level.

Remarks.--Extensive diurnal fluctuation and slight regulation caused by power plants above station. City of Little Falls diverts about 5 cfs for municipal supply.

Table 5.--Miscellaneous discharge measurements of the Mohawk River and tributaries

Date	Site	Discharge (cfs)
6/13/66	Mohawk River at Canal Gate # 6 near Rome	67.2
6/14/66	Mohawk River at Oriskany Rd. nr. Oriskany	263
9/ 7/66	do.	358
5/30/67	do.	221
8/10/67	do.	1,200
5/ 5/66	Oriskany Creek at Oriskany	205
Do.	do.	206
6/14/66	do.	130
5/31/67	Mohawk River at 12C Bridge nr. Whitesboro	308
6/13/66	Mohawk River at Mohawk St., nr. Whitesboro	370
6/14/66	do.	372
9/ 7/66	do.	422
5/29/67	do.	238
5/30/67	do.	394
8/10/67	do.	2,010
8/11/67	do.	848
5/ 5/66	Sauquoit Creek at Whitesboro	91.2
Do.	do.	87.5
6/13/66	do.	55.7
6/14/66	Mohawk River at N.S. Arterial, Utica	438
6/15/66	do.	705
8/ 8/67	do.	491
6/15/66	Mohawk River at Leland Ave., Utica	695
9/ 7/66	do.	313
9/ 7/66	do.	374
8/ 9/67	do.	449
6/16/66	Mohawk River at Schuyler (Dyke Rd.)	705
9/ 8/66	do.	578
8/15/67	do.	673
6/16/66	Mohawk River nr. Frankfort (Susp. Br.)	758
9/ 8/66	do.	578
8/16/67	do.	478
6/20/66	Mohawk River at Frankfort	879
5/24/67	do.	746
5/30/67	do.	742
6/20/66	Mohawk River at Washington St., Herkimer	498
5/24/66	do.	769
6/21/66	Mohawk River at Lock 18 near Herkimer	1,160
6/23/66	do.	1,140
5/23/67	do.	2,450
8/17/67	do.	980
6/22/66	Mohawk River at S. Ann St., Little Falls	1,310
5/22/67	do.	3,140
7/11/66	Caroga Creek at Palentine Church	162
5/ 6/66	Canajoharie Creek at Canajoharie	44.6
Do.	do.	48.9
Do.	do.	55.2
7/11/66	Mohawk River at Ft. Plain	1,200
5/10/67	do.	5,450
8/ 1/66	Mohawk River at Fonda	803
8/ 2/66	do.	631
5/ 8/67	do.	7,020
5/19/66	N. Chuctanunda Creek at Amsterdam	101
5/19/66	do.	132
5/19/66	do.	175
7/27/66	do.	14.4
7/27/66	Mohawk River at Amsterdam	974
5/ 9/67	do.	10,000
7/25/66	Mohawk River at Rotterdam Junction	968
5/18/67	do.	7,930
7/18/66	Mohawk River at Rt. 50 Bridge, Schenectady	1,120
7/20/66	do.	1,880
5/ 8/67	do.	6,620

ANALYSIS

Time of travel varies considerably in the study reach with changes in discharge, channel cross section, and channel use. The major controlling factor in most of the reach is the operation of the Erie Barge Canal. In the easternmost part of the study reach, from just above Vischer Ferry to the Crescent Dam, hydroelectric power production plays an important role in controlling the time of travel. All these variables and controls combine to produce three basic channel types: the natural river section, the river-canal section, and the power-pool section. Figure 4 shows a schematic diagram of the three types of channel encountered.

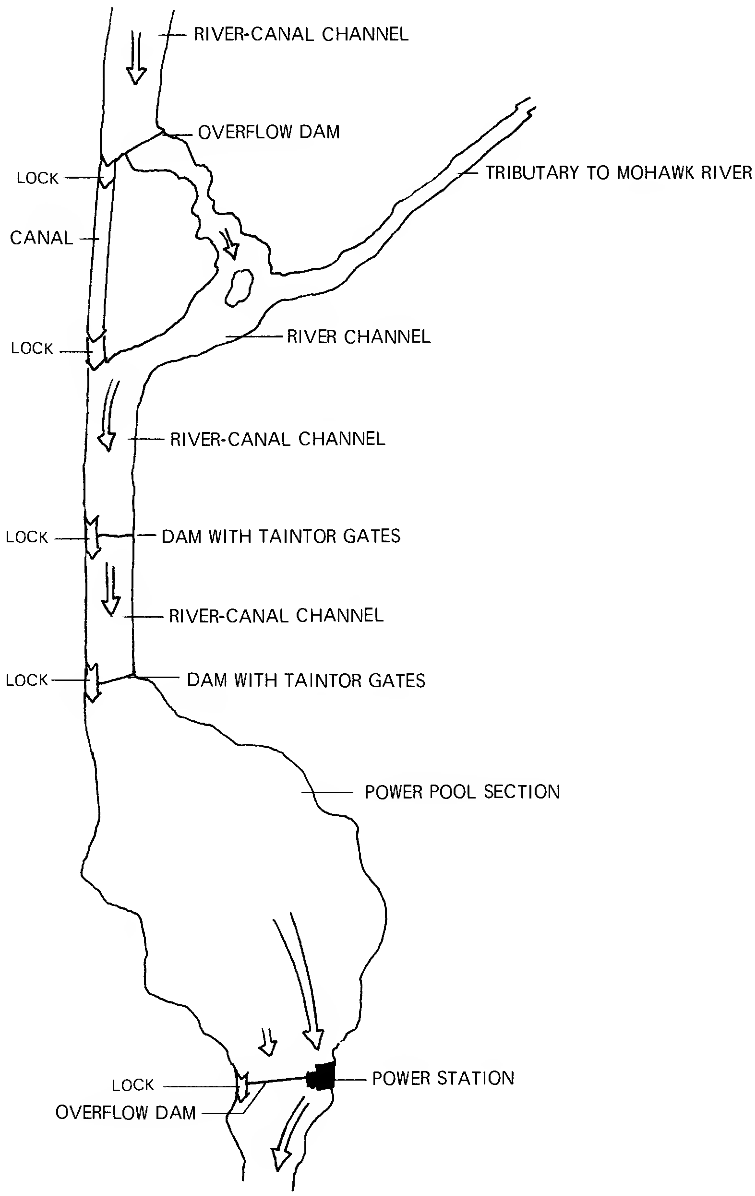

Figure 4.--Channel types of Mohawk River.
Arrows show major flow path.

Time of Travel in the Natural River Sections

The natural river sections are used mainly as overflow channels into which the excess flow in the canal is diverted. Once diverted, the water flows independently of the canal until it re-enters the canal system in the combined river-canal section. In comparison with the other sections, the natural river sections can be characterized as having the shallowest depths, and the most sinuous channels. Partly because of the first factor, time of travel in the natural river sections is less than that for the other sections, especially during periods of low discharge.

Because the natural river sections do not have, to such a great extent, the two distinct flow patterns of the canalized sections, but rather have a more distributed flow regime, it was possible to estimate the relationship of time of travel to discharge. These relationships are shown in figures 6 to 14 based on the data in table 6. The time variation in dye-concentration curves is shown in appendix A.

Except for the Leland Avenue section, the flow in the natural river channel is generally not affected by in-channel regulation from such things as gates, dams, and locks. There are, however, regulatory influences produced by the feeder and tributary inflow to the natural river channel.

Feeder canals cause fluctuation in the headwaters of the natural river sections. The subreach from Guard Gate No. 6 near Rome to Mohawk Street, Whitesboro, is supplied by Ninemile Feeder through Ninemile Creek. Strong diurnal fluctuations are caused in the Herkimer to Lock 18 subreach by West Canada Creek, and the Fivemile Dam to Lock 16 subreach is affected by East Canada Creek. Both East and West Canada Creeks are highly regulated by hydroelectric power stations during mid- and low-flow periods.

Time of Travel in the River-Canal Sections

In the river-canal sections the river channel has been modified by means of straightening and dredging to accommodate canal traffic. The channel then becomes a series of pools separated by locks. The flow is controlled by Taintor gates which act as dams at the locks. When high flows occur, the excess water is passed downstream through the opened gates. After the high flow has passed, the gates are closed to maintain the canal level. There are two distinct flow patterns during the canal-operating season: the high flow and low flow. The high-flow period, which usually occurs around the middle of May, has a short time of travel because of the necessity of lowering the canal pools by frequently opening the Taintor gates. The low-flow period which comprises the summer season is characterized by closed gates and an extended time of travel. Runs were made only during high- or low-flow periods, there being no significant periods of median flows. The low-flow run was made in the summer of 1966 and the high flow in the spring of 1967.

The results of the two runs are given in table 6. The increased velocity noted during periods of high discharge are caused in the river-canal sections by two factors, the increased discharges, and the opening

Table 6.--Time-of-travel data

Reach	Mileage	First Run Date	First Run Discharge (cfs)	First Run Time (hrs., min.)	First Run Velocity (fps)	Second Run Date	Second Run Discharge (cfs)	Second Run Time (hrs., min.)	Second Run Velocity (fps)	Third Run Date	Third Run Discharge (cfs)	Third Run Time (hrs., min.)	Third Run Velocity (fps)
Guard Gate 6 nr. Rome (122.0)		6/13/66	67.2			5/29/67							
to Oriskany Rd., Oriskany (116.5)	5.5	6/14/66	263	16:00	0.50	5/30/67	221	16:30	0.49	8/10/67	1,200	12:45	0.63
to Mohawk St., Whitesboro (111.7)	4.8	6/14/66	372	7:15	.97	5/29-30/67	394	6:15	1.13	8/10-11/67	1,380	3:30	2.01
Total	10.3			23:15				22:45				16:15	
Mohawk St., Whitesboro (111.7)		6/13/66	370										
to North South Arterial, Utica (107.0)	4.7	6/14/66	438	11:25	.60	8/ 8/67	491	9:45	.71				
to Leland Ave., Utica (105.0)	2.0	6/15/66	695	6:05	.48	8/8-9/67	449	8:30	.34				
to Leland Ave. Dam (104.8)	.2			e/:35				e/:52					
Total	6.9			18:05				19:07					
Leland Ave. Dam, Utica (104.8)													
to Dyke Rd., Schuyler (99.6)	5.2	6/15/66	705	6:35	1.16	9/ 8/66	600	8:30	.90	8/15/67	600	8:30	.90
to Suspension Bridge nr. Frankfort (93.8)	5.8	6/16/66	758	7:45	1.10	9/ 8/66	561	12:10	.70	8/15-16/67	580	11:45	.72
to Frankfort (93.0)	.8			e/1:05				e/1:40					
Total	11.8			15:25				22:20					
Frankfort (93.0)													
to Herkimer (88.2)	4.8	6/20/66	879	14:00	.50	5/30/67-6/1/67	742	32:00	.22				
Herkimer Guard Gate 5 (88.2)													
to Lock 18 (83.6)	4.6	6/21/66	1,360	6:00	1.12	5/24/67	2,020	3:15	2.08	8/17/67	980	7:30	.90
Lock 18, Herkimer (83.6)		6/23/66	1,140			5/23/67	2,450						
to Hansen Island, Little Falls (80.4)	3.2	6/24/66		14:15	.33	5/23/67		7:00	.67				
Hansen Island, Little Falls (80.4)													
to Lock 17 (79.3)	1.1	6/22/66	1,310	2:10	.74	5/22/67	3,140	1:05	1.49				
to Fivemile Dam (75.5)	3.8		1,390	19:00	.29	5/22/67	3,460	7:25	.75				
Total	4.9			21:10				8:30					
Fivemile Dam (75.5)													
to Lock 16 (71.1)	4.4	7/ 7/66	1,840	5:15	1.23	10/11/66	2,000	4:45	1.36	5/11/67	4,660	2:50	2.28
Lock 16 (71.1)													
to Lock 15 (64.5)	6.6	7/11/66	1,200	34:15	.28	5/11/67	5,450	12:00	.81				
Lock 15 (64.5)													
to Lock 14 (61.0)	3.5	7/11/66	1,200	20:15	.25	5/10/67	5,450	8:00	.64				
Lock 14 (61.0)													
to Lock 13 (53.2)	7.8	7/12-15/66	1,200	68:00	.17	5/10-11/67	5,450	14:15	.80				
Lock 13 (53.2)													
to Fonda (48.6)	4.6	8/ 1/66	803	50:00	.13	5/10/67	a/8,000	8:00	.84				
to Lock 12 (43.5)	5.1	8/ 2/66	631	49:30	.15	5/ 8/67	7,020	9:30	.79				
Total	9.7			99:30				17:30					
Lock 12 (43.5)													
to Lock 11 (39.2)	4.3	7/26/66	974	40:30	.16	5/ 9/67	10,000	8:00	.79				
Lock 11 (39.2)													
to Lock 10 (34.9)	4.3	7/26/66	974	43:00	.15	5/ 9/67	10,000	5:40	1.11				
Lock 10 (34.9)													
to Lock 9 (28.9)	6.0	7/25/66	968	63.30	.14	5/18/67	7,930	9:15	.95				
Lock 9 (28.9)													
to Lock 8 (24.0)	4.9	7/25/66	968	51:30	.14	5/18/67	7,930	7:45	.93				
Lock 8 (24.0)													
to N.Y. Hwy. 50, Schenectady (19.9)	4.1	7/18/66	1,120	19:30	.31	5/ 8/67	7,250	6:30	.92				
		7/20/66	1,880 (1,500)										
to Lock 7 (13.1) (Vischers Ferry)	6.8		a,c/940	80:00	.12	5/8-9/67	a,c,/ 7,250	a/16.00	.62				
Total	10.9			99:30				22:30					
Lock 7 (13.1) (Vischers Ferry)													
to Crescent Dam (2.9)	10.2		a,c/1,000	a/170:00		5/8-9/67	a,c,/ 8,060	21:00	.71				

a/ About. c/ From Power Station Records. e/ Estimated by extending time of previous section.

of the gates and dams to expedite the passage of the water. The relationship of time of travel to discharge for the canal sections is also shown in figures 6 to 14; these graphs can be used to determine time of travel for flow rates different from those observed during this study.

Time of Travel in the Power-Pool Sections

The river in these sections could also be considered a river-canal section but hydroelectric power stations produce the major influence on the time of travel. This study included the power-pool subreaches above the Vischer Ferry station and above the Crescent power station. In these reaches the flow of water depends on (1) the water available, (2) the capacity of pond, and (3) the scheduling of power needs. During low flows, water is ponded and saved for peak production hours, thereby causing lengthy times of travel. During low flow, the periods of ponding generally occur at night and are so arranged as to be able to produce power Monday through Friday for the 10 daylight hours. During high flows, power is produced constantly and excess water is passed through gates without even entering the power stations; this causes brief times of travel. As with the river-canal sections, runs were attempted only at periods of high and low flows.

The length of time the dye cloud persisted before being carried away by the streamflow was different for high and low flows. The average time during a period of low flow was 77 hours, while that during a high-flow period was 10 hours. Various curves illustrating the time variation in dye concentrations are given in appendix A. Appendix B shows cross sections measured during the study.

DISCUSSION

Under ideal conditions, time-of-travel studies should be made at three well-distributed discharges as defined by a flow-duration curve. This is necessary to properly define the relationship of time of travel to discharge. The low discharge under ideal conditions would be at approximately the 99-percent duration.

The only long-term station on the Mohawk River within the study reach is "The Mohawk River near Little Falls"; the flow-duration curve is shown in figure 3 and the station described in table 4. This station record shows that during the period of study a sustained low flow of 99-percent duration is not available. Brief periods of this low flow were reached, but only for short time periods as caused by regulation over Sunday night and Monday mornings.

Because of regulation, such well-distributed flows do not occur in the river-canal section. The flow duration was estimated to be the same as was found at Little Falls during the same time period (approximately 30 percent for the high flows, 85 percent for the low flows, with variations throughout the period).

The same procedure must be followed in estimating the flow duration in the river-channel sections. This is much more difficult because of the tendency toward erratic high flows in the headwaters and because of regulation of the tributaries above the station. The ranges of flow duration during the periods of study for the river reaches were as follows:

Guard Gate No. 6 to Mohawk St., 24 to 72 percent;
Mohawk St. to Leland Ave., 55 to 72 percent;
Leland Ave. Dam to Suspension Bridge, 44 to 70 percent;
Herkimer to Lock 18, 40 to 78 percent;
Hansen Island to Lock 17, 24 to 64 percent; and
Fivemile Dam to Lock 16, 26 to 82 percent.

To demonstrate the variation in time of travel encountered during the study, figure 5 shows the maximum and minimum cumulative times found from Guard Gate No. 6 near Rome to Crescent Dam near Cohoes. The maximum cumulative time of travel is of special interest in regards to pollutant studies because it occurs during low-discharge periods.

Using the relationships established in this report it is possible to estimate the time of travel, given the discharge, for any of the subreaches covered in this report.

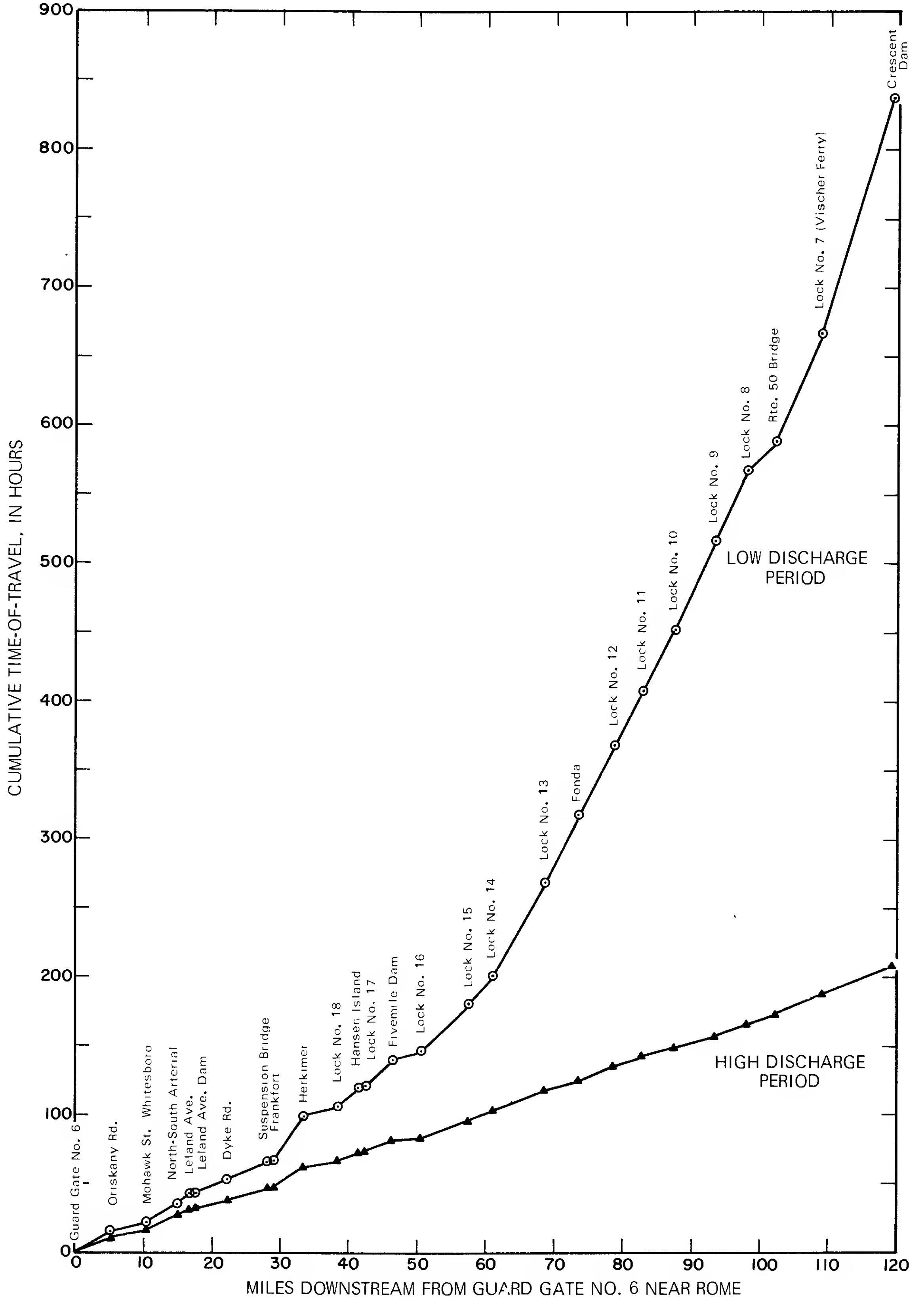

Figure 5.--Cumulative time of travel from Guard Gate No. 6 to Crescent Dam for observed high and low discharges.

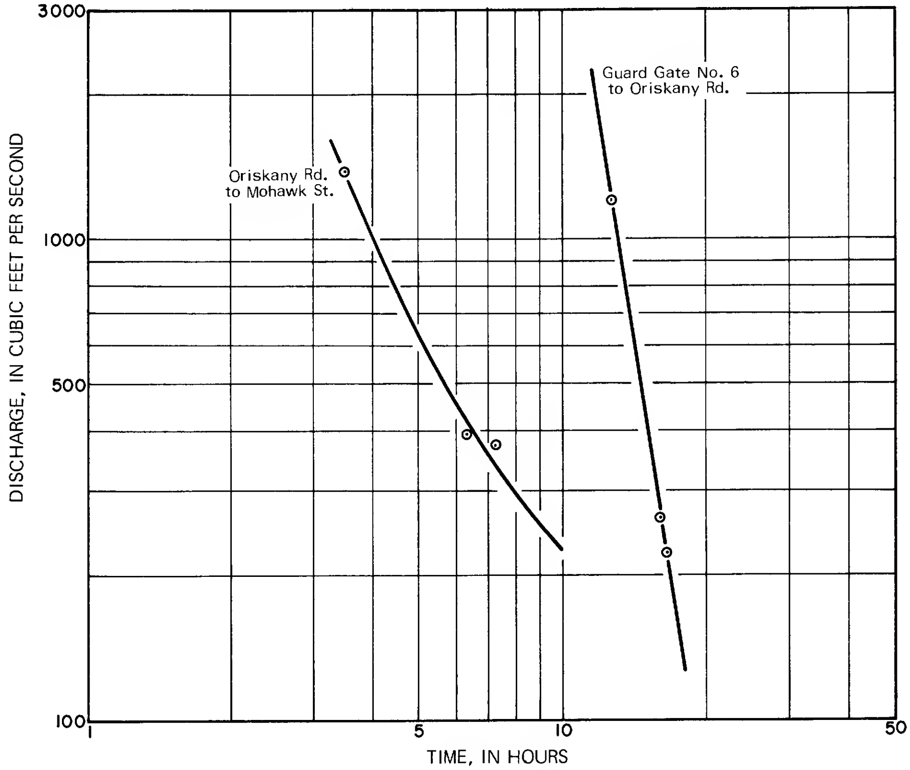

Figure 6.--Relationship of discharge to time of travel on the Mohawk River (from Guard Gate No. 6 near Rome to Oriskany Road to Mohawk Street).

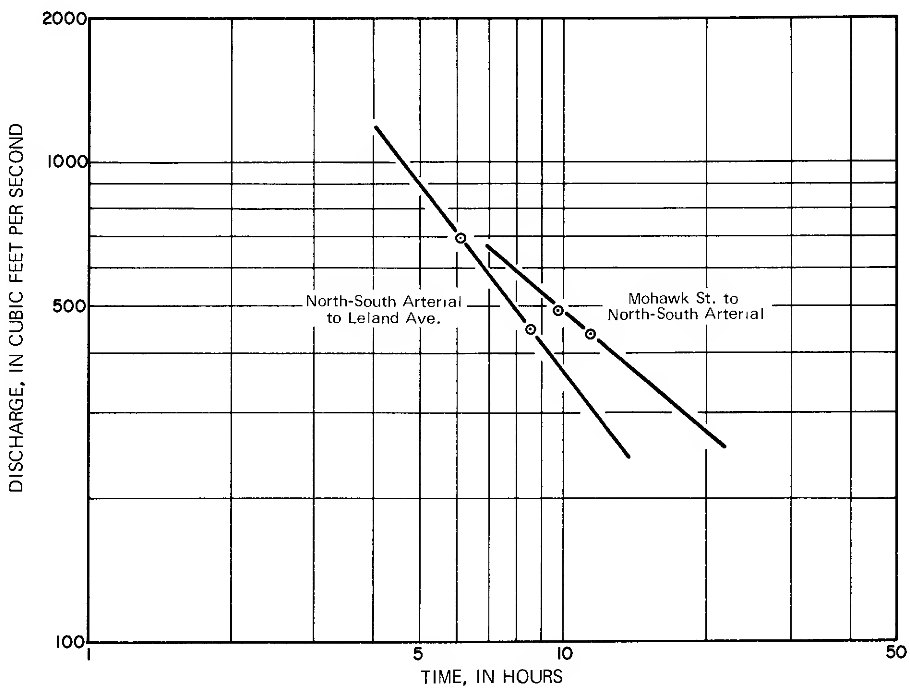

Figure 7.--Relationship of discharge to time of travel on the Mohawk River (from Mohawk Street to North-South Arterial to Leland Avenue, Utica).

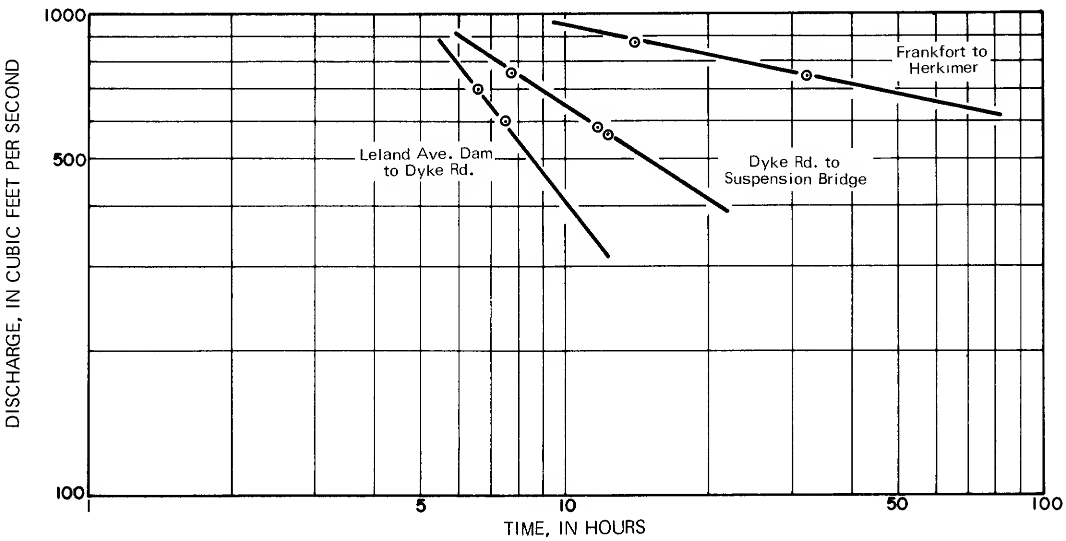

Figure 8.--Relationship of discharge to time of travel on the Mohawk River (from Leland Avenue Dam to Dyke Road to Suspension Bridge, and Frankfort to Herkimer).

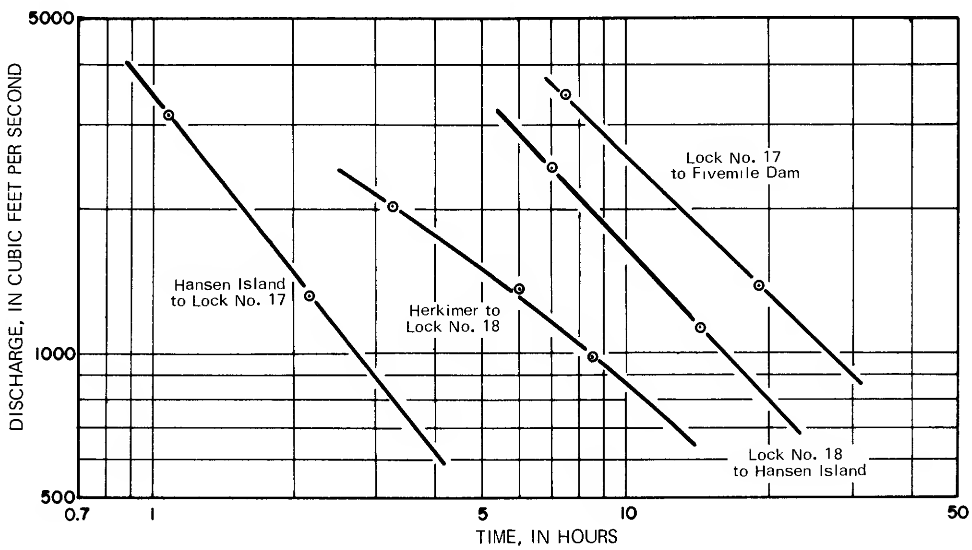

Figure 9.--Relationship of discharge to time of travel on the Mohawk River (from Herkimer to Lock 18 to Hansen Island to Lock 17 to Fivemile Dam).

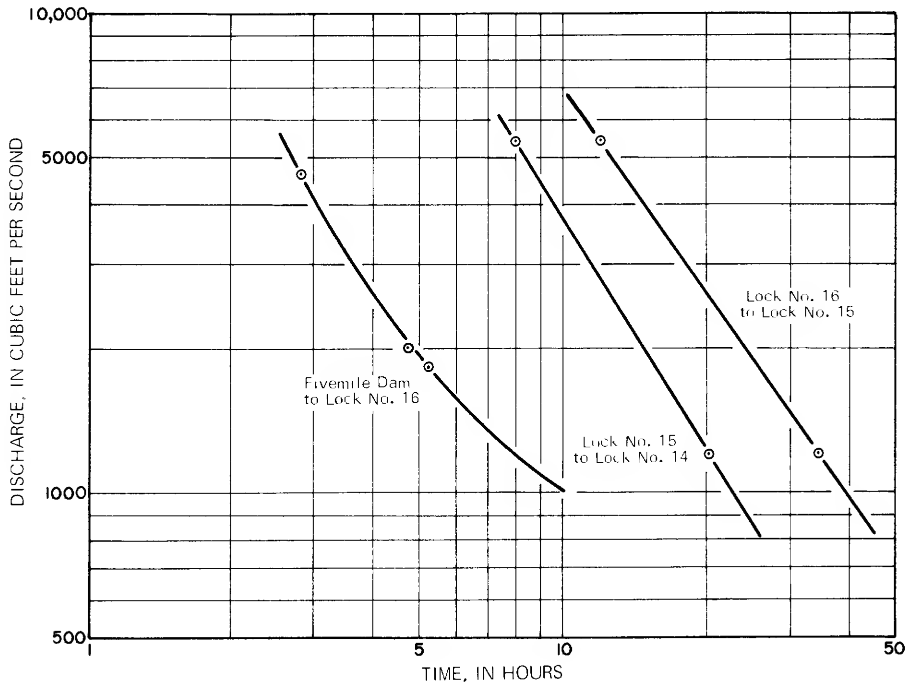

Figure 10.--Relationship of discharge to time of travel on the Mohawk River (from Fivemile Dam to Lock 16 to Lock 15 to Lock 14).

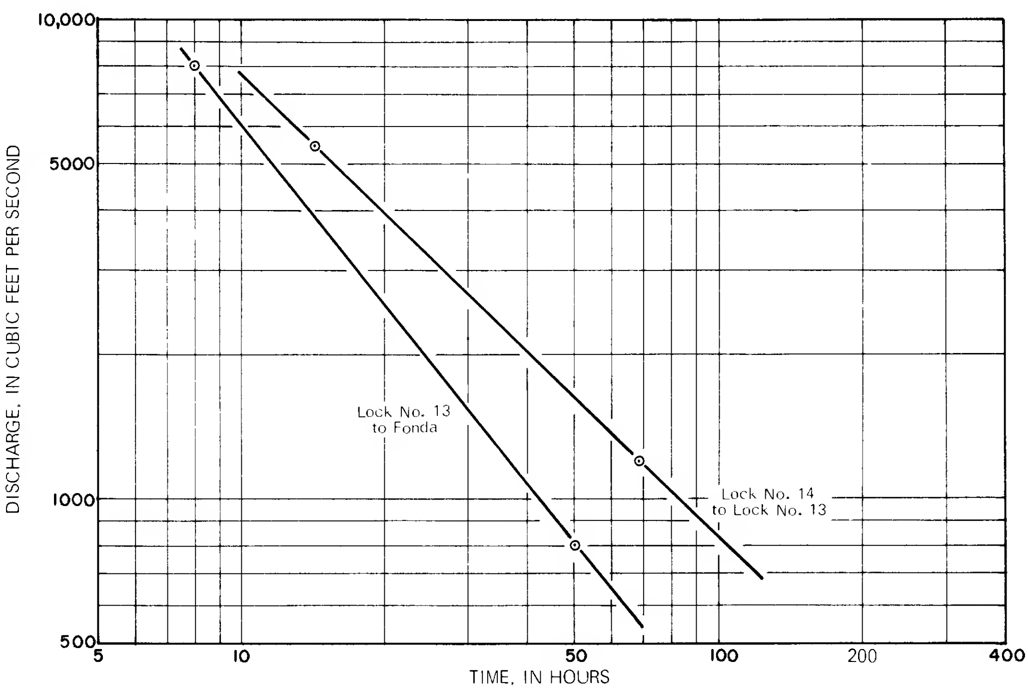

Figure 11.--Relationship of discharge to time of travel on the Mohawk River (from Lock 14 to Lock 13 to Fonda).

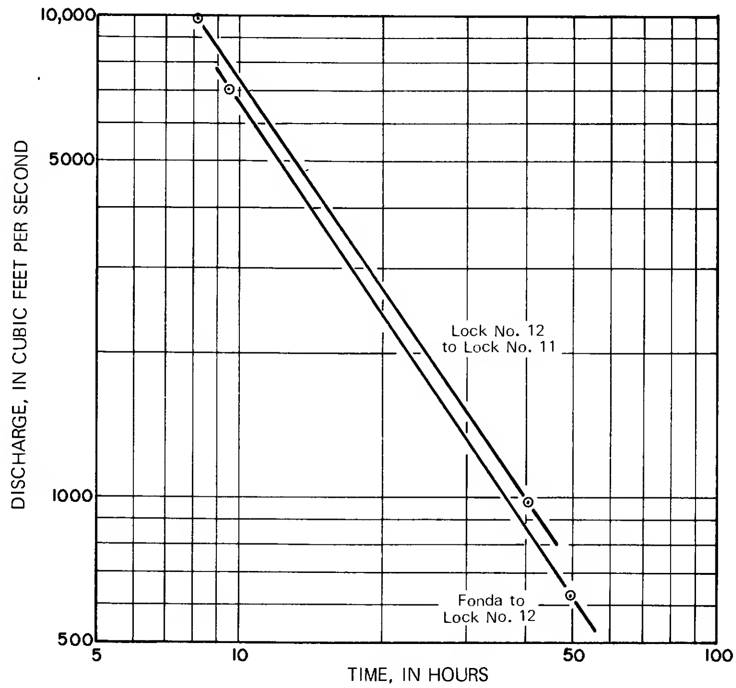

Figure 12.--Relationship of discharge to time of travel on the Mohawk River (from Fonda to Lock 12 to Lock 11).

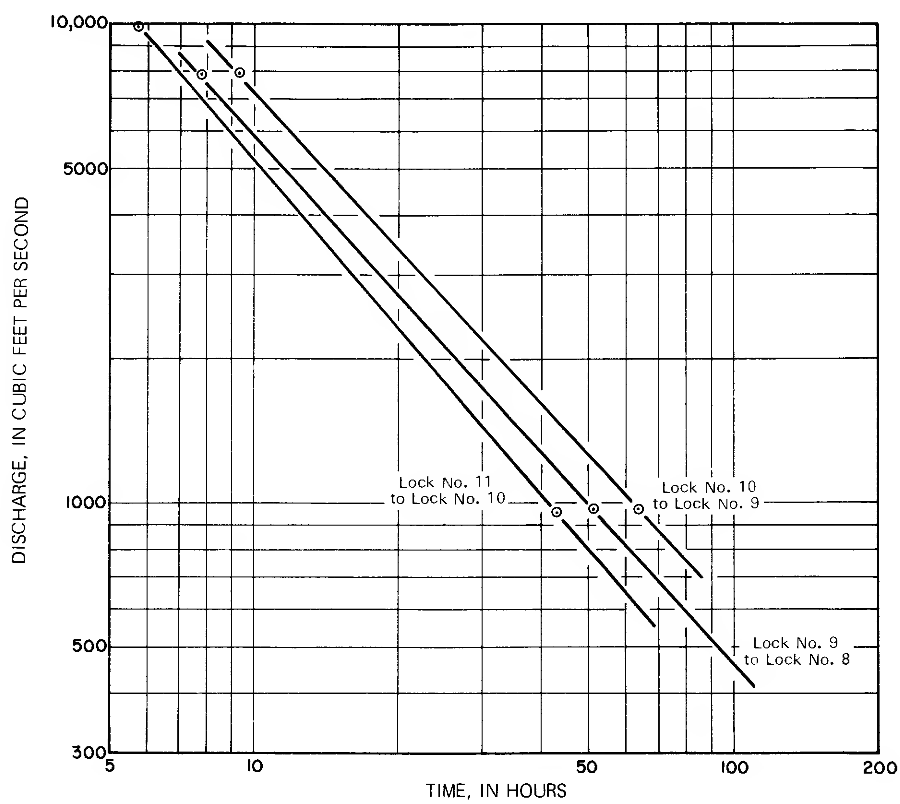

Figure 13.--Relationship of discharge to time of travel on the Mohawk River (from Lock 11 to Lock 10 to Lock 9 to Lock 8).

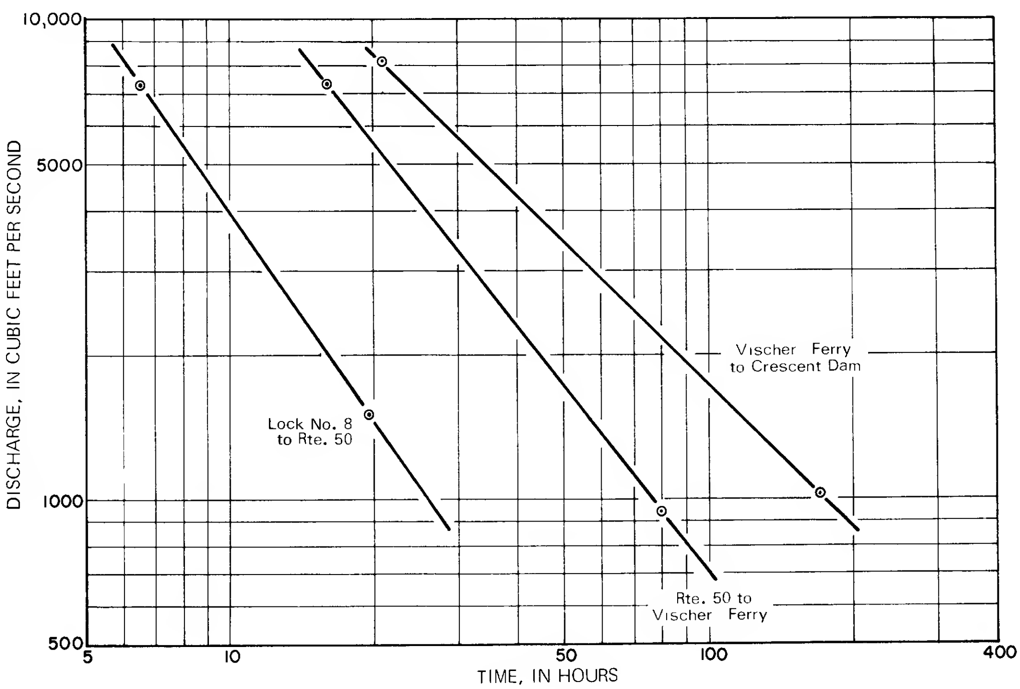

Figure 14.--Relationship of discharge to time of travel on the Mohawk River (from Lock 8 to Route 50 to Vischer Ferry to Crescent Dam).

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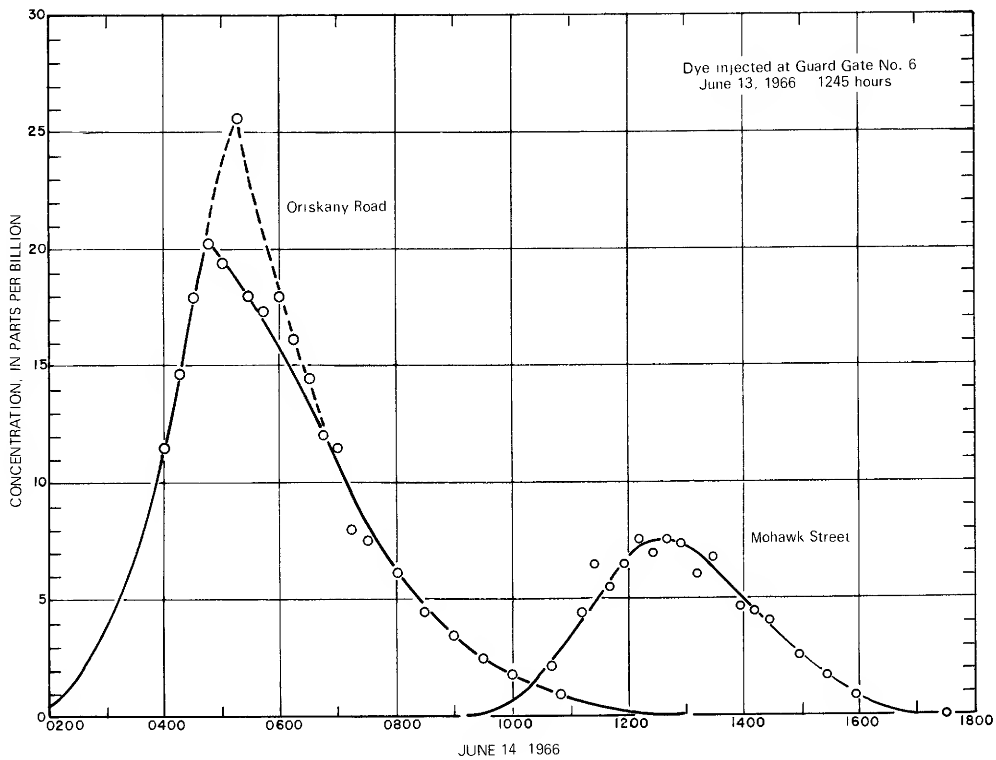
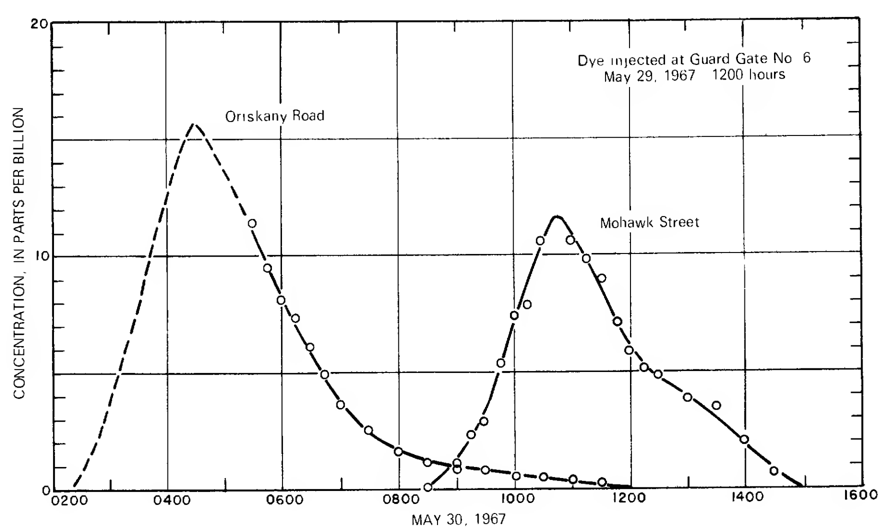
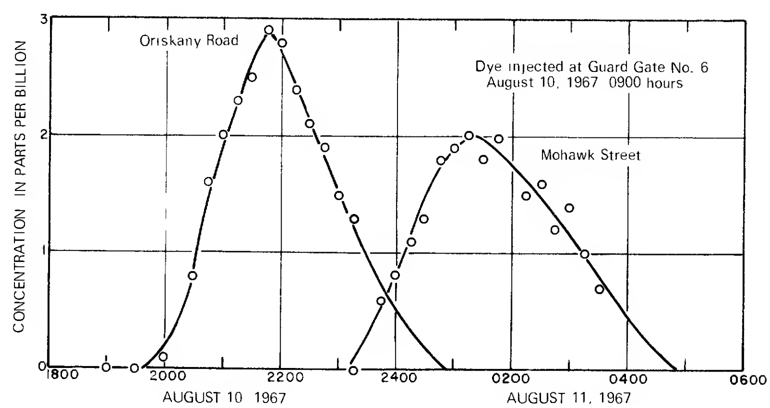
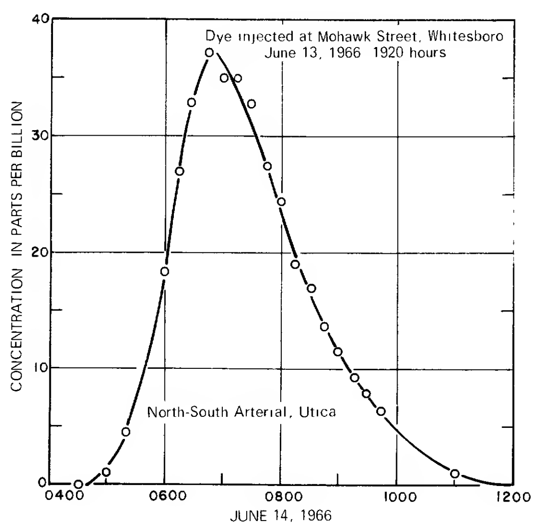




Appendix A.--Time variation and dispersion of dye.





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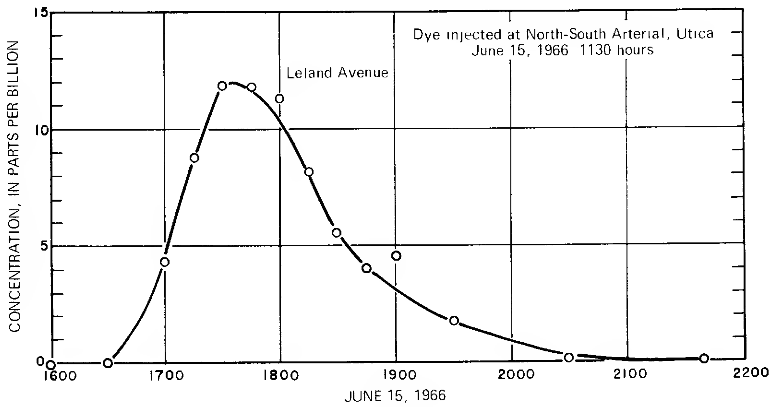

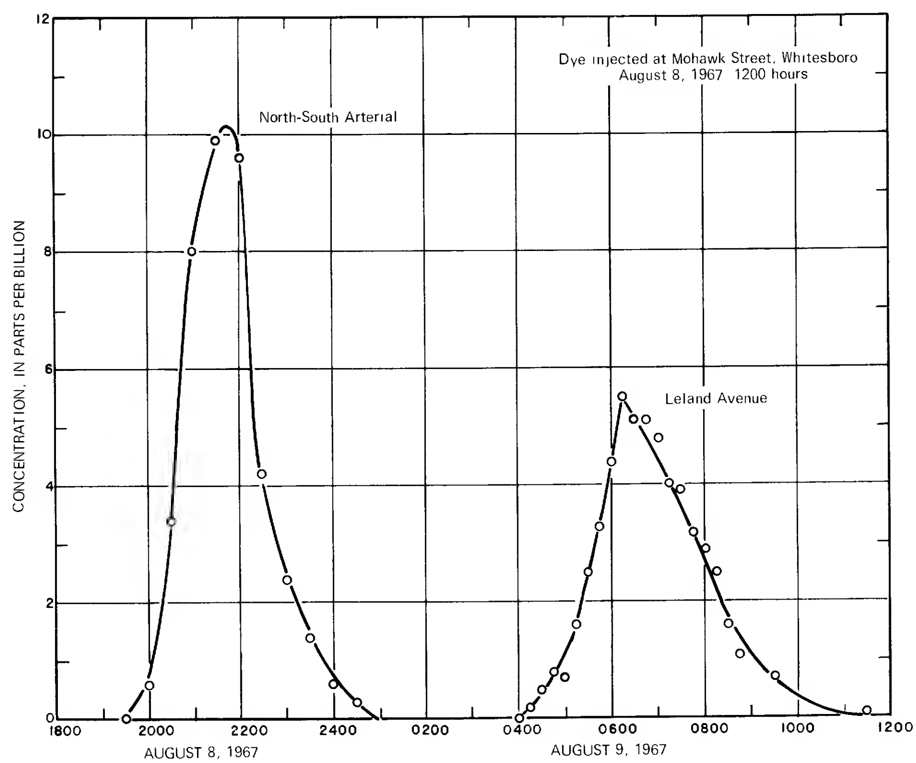

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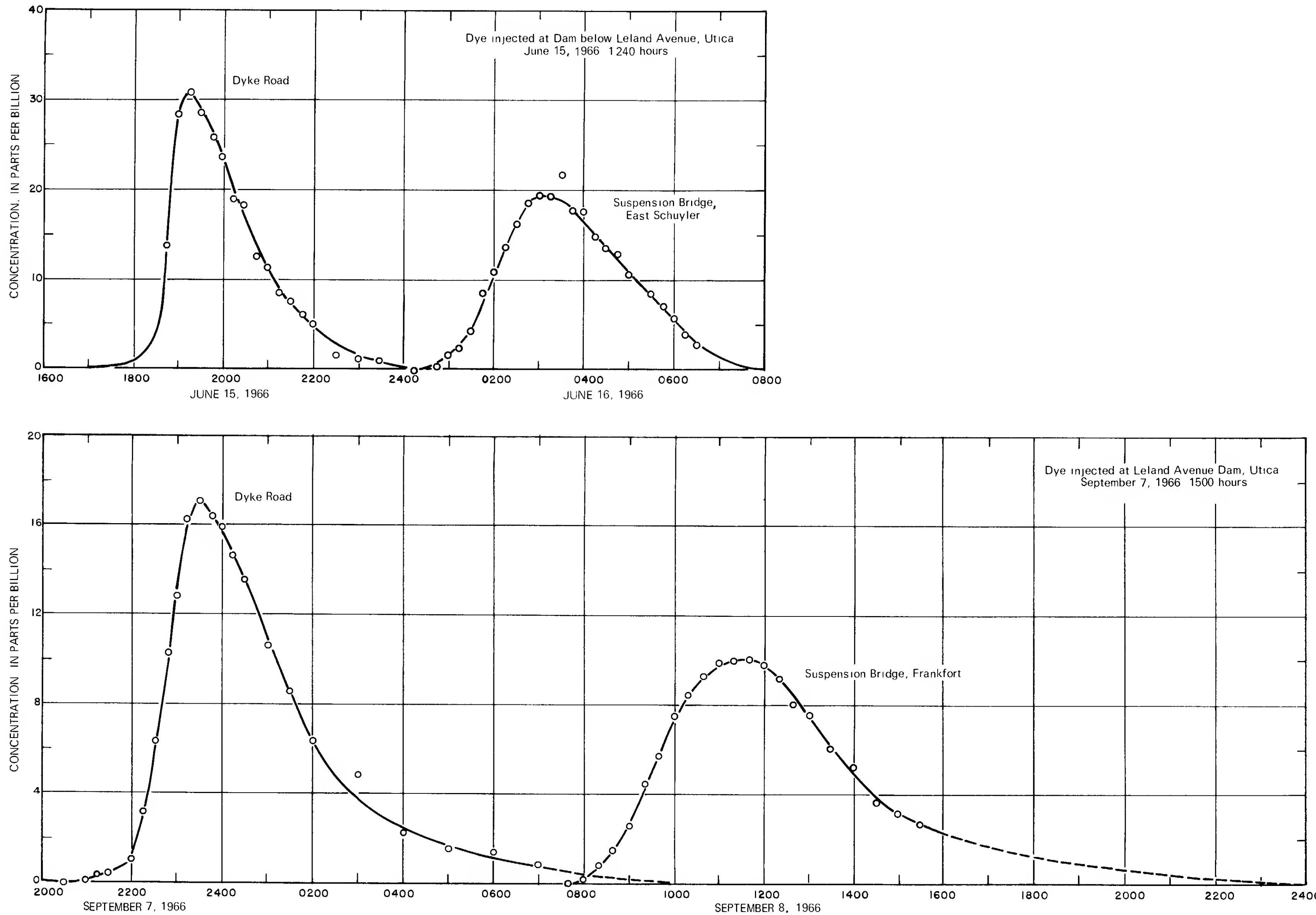

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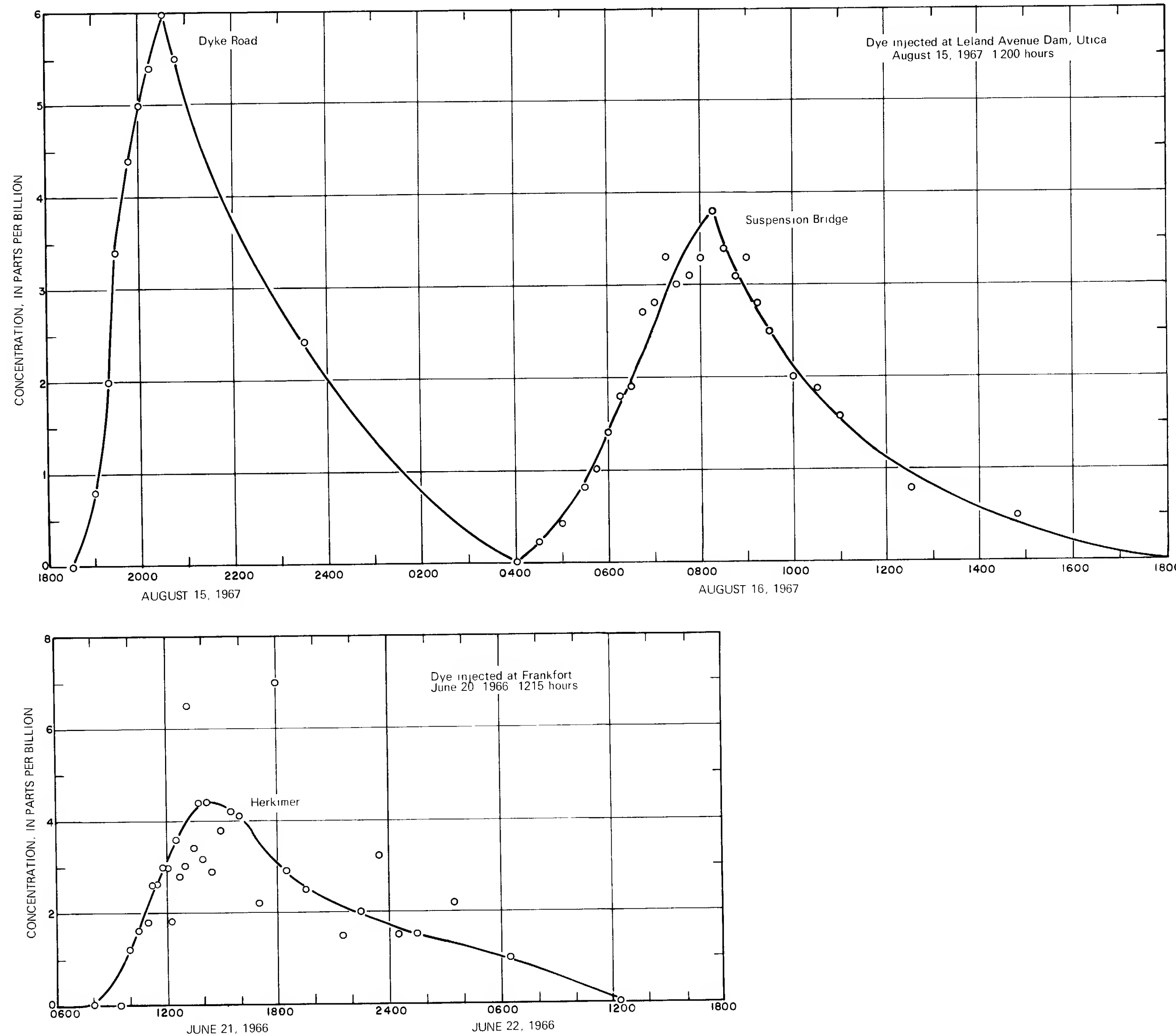

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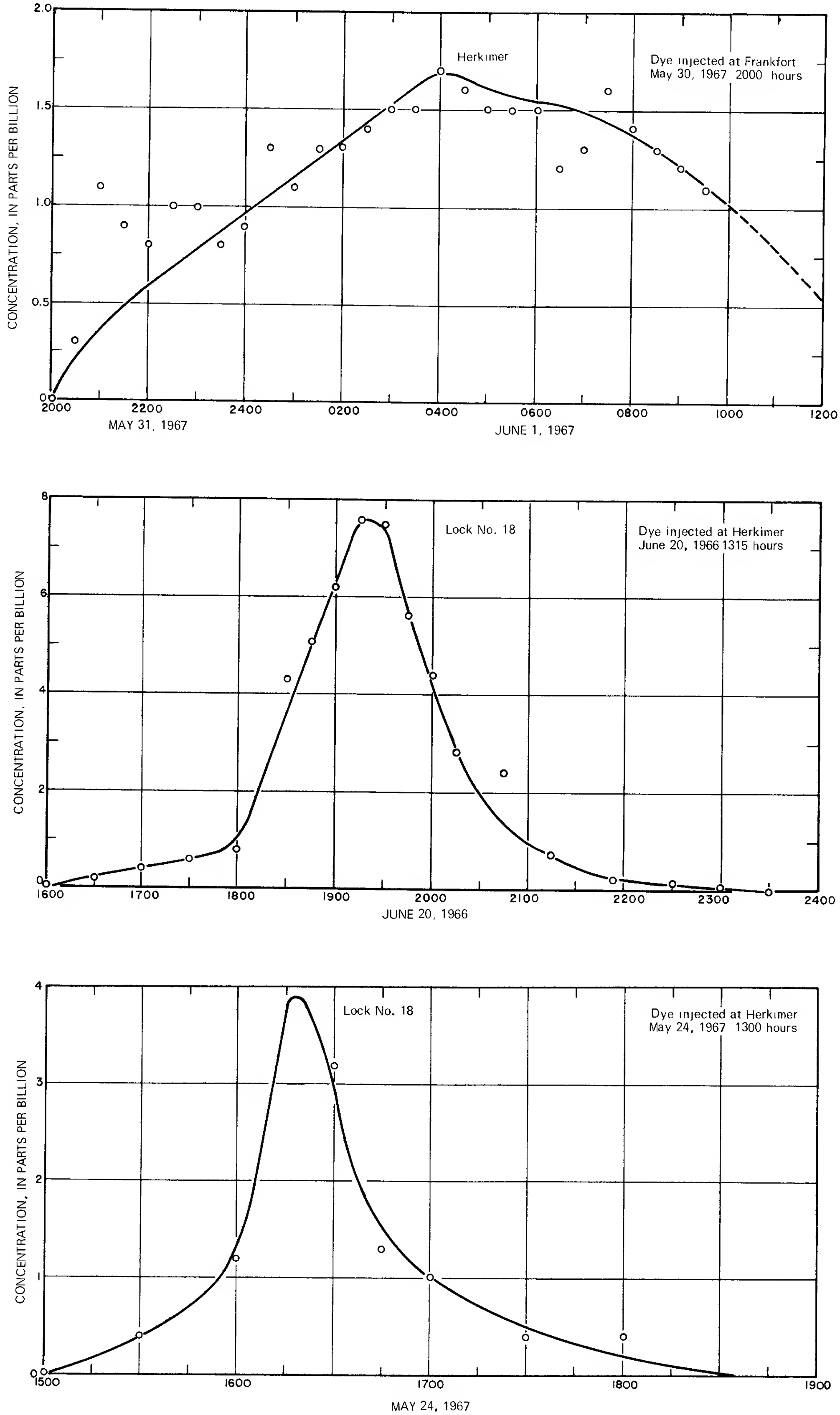

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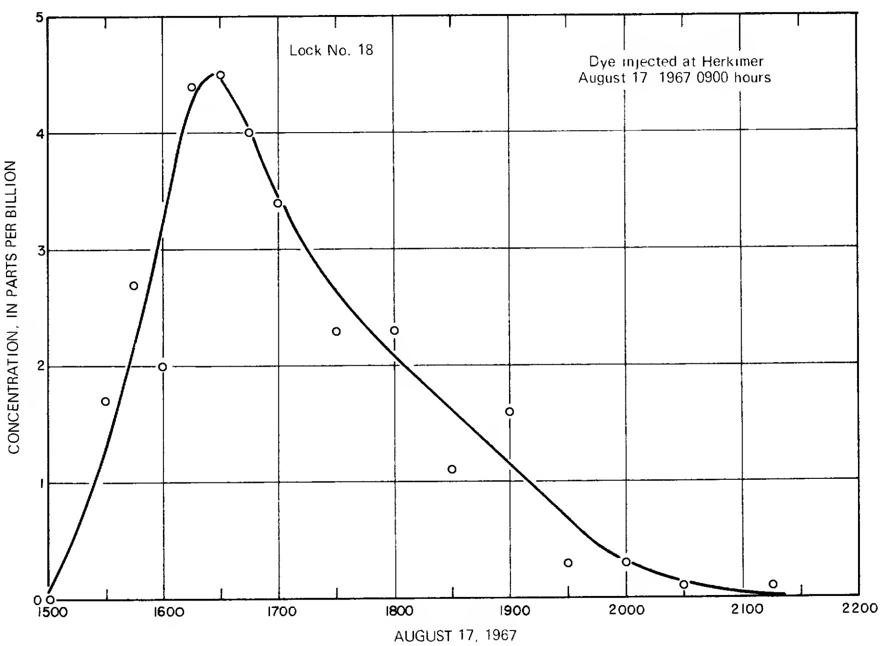

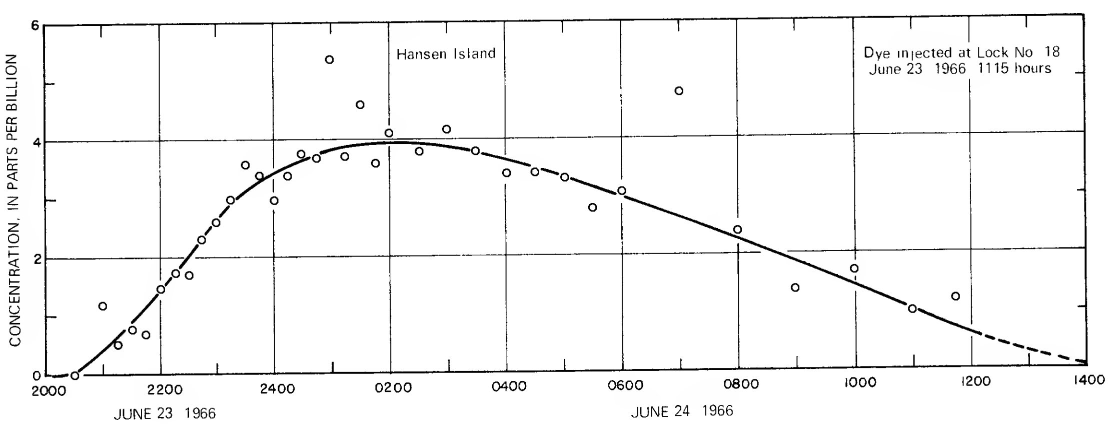

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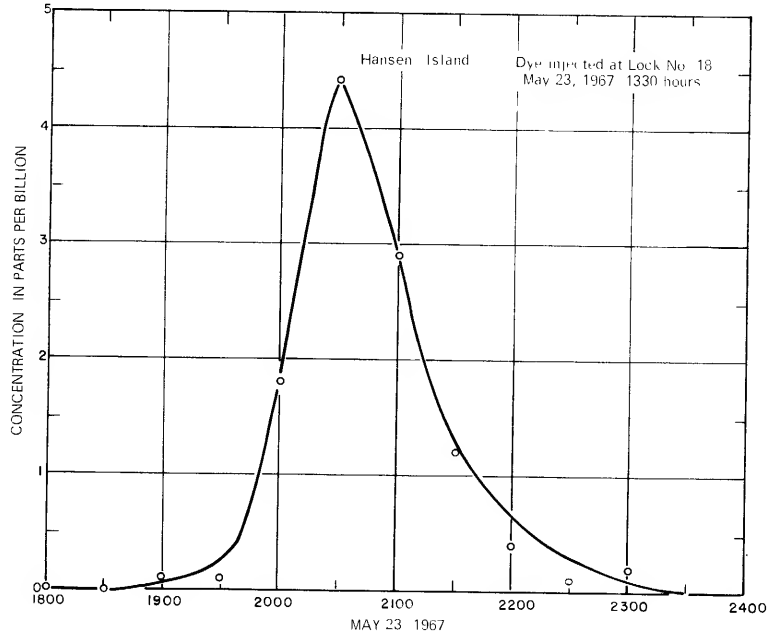

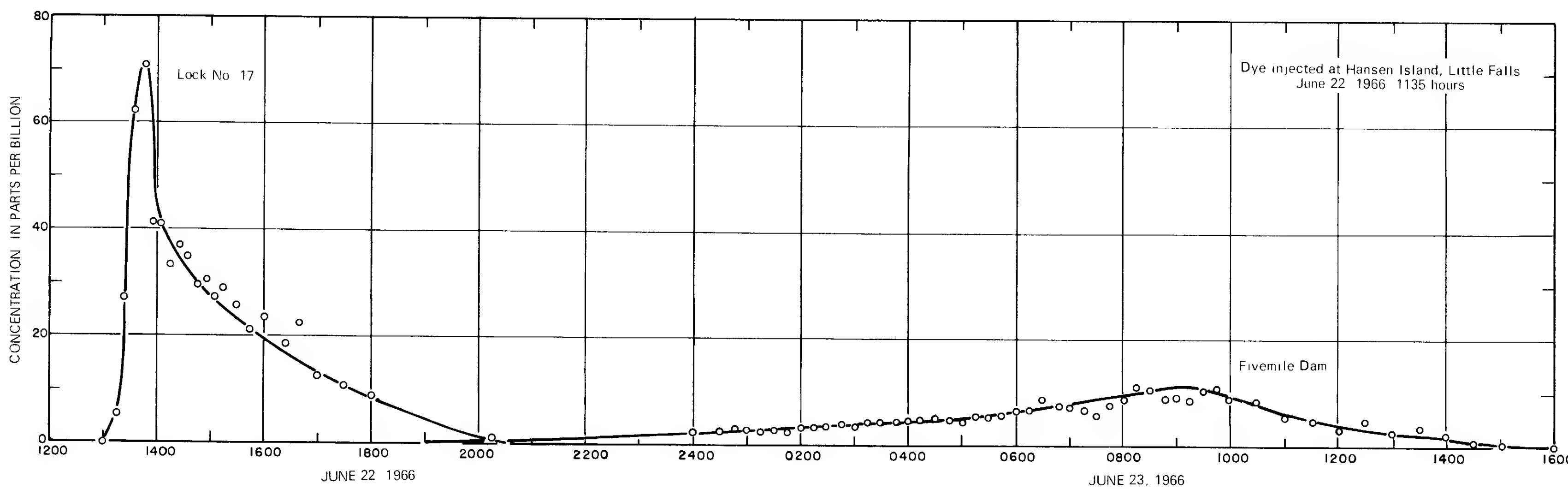

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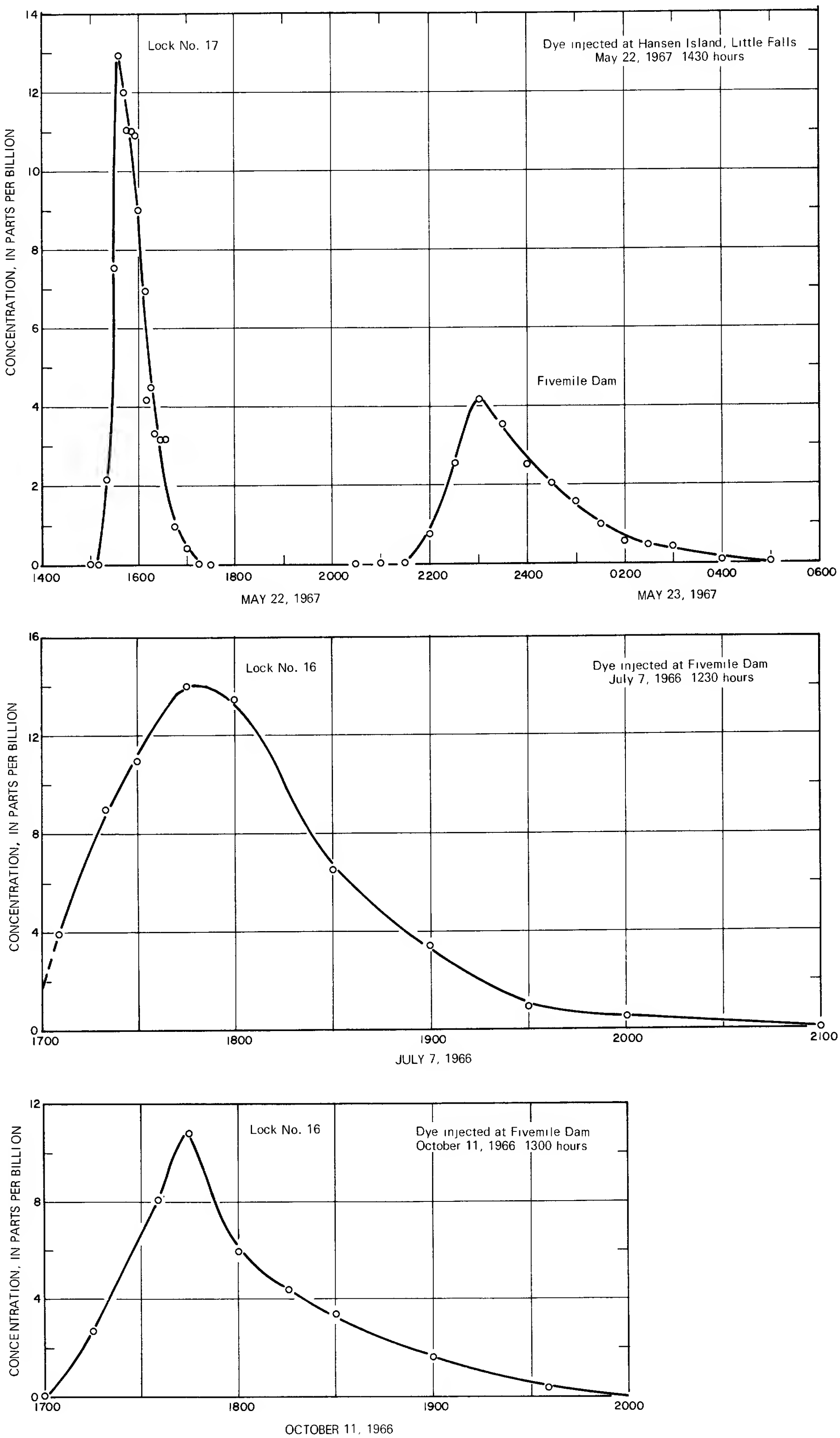

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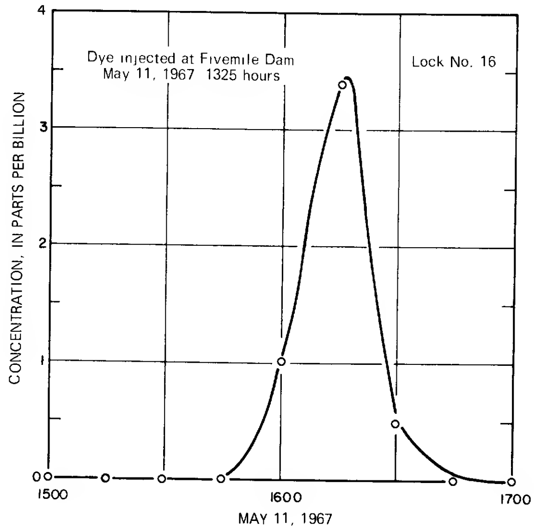

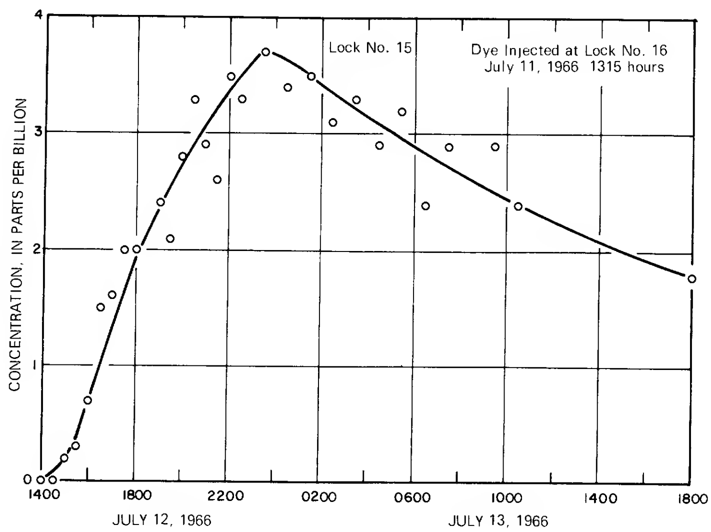

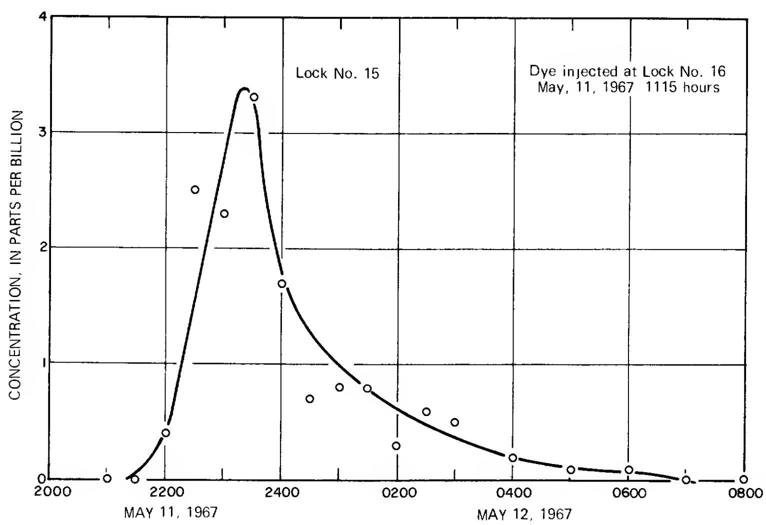

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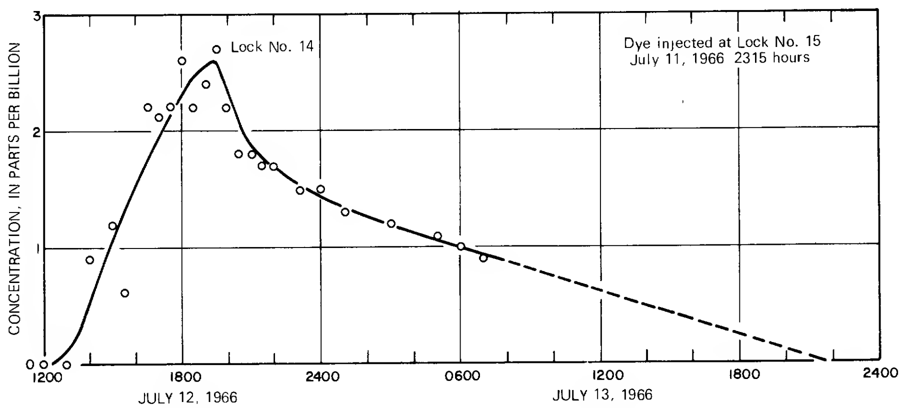

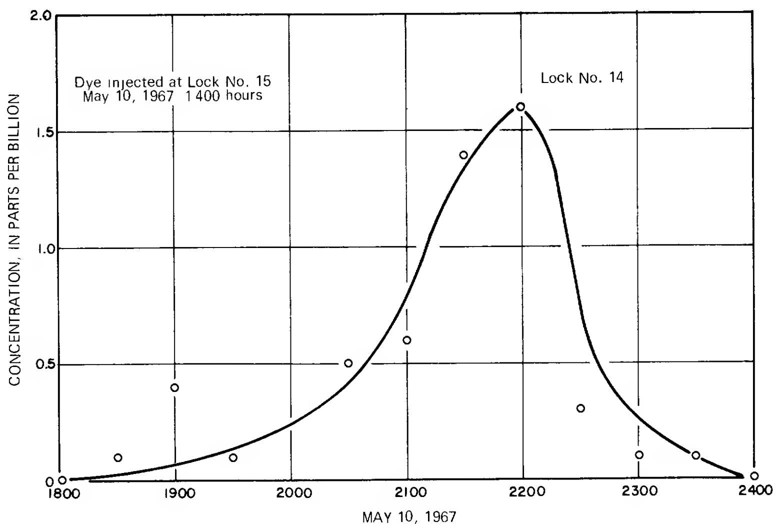

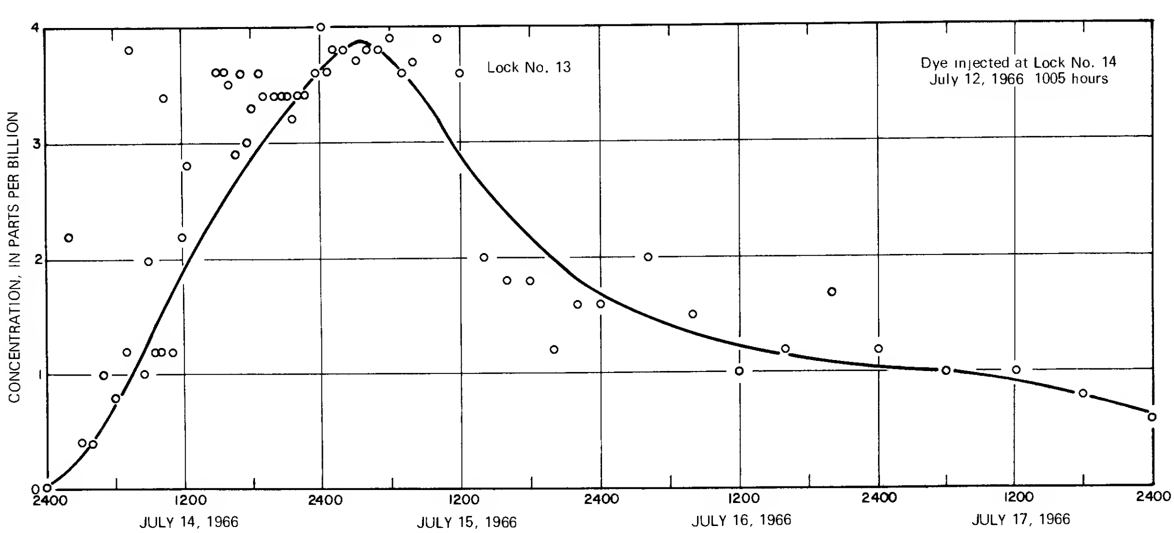

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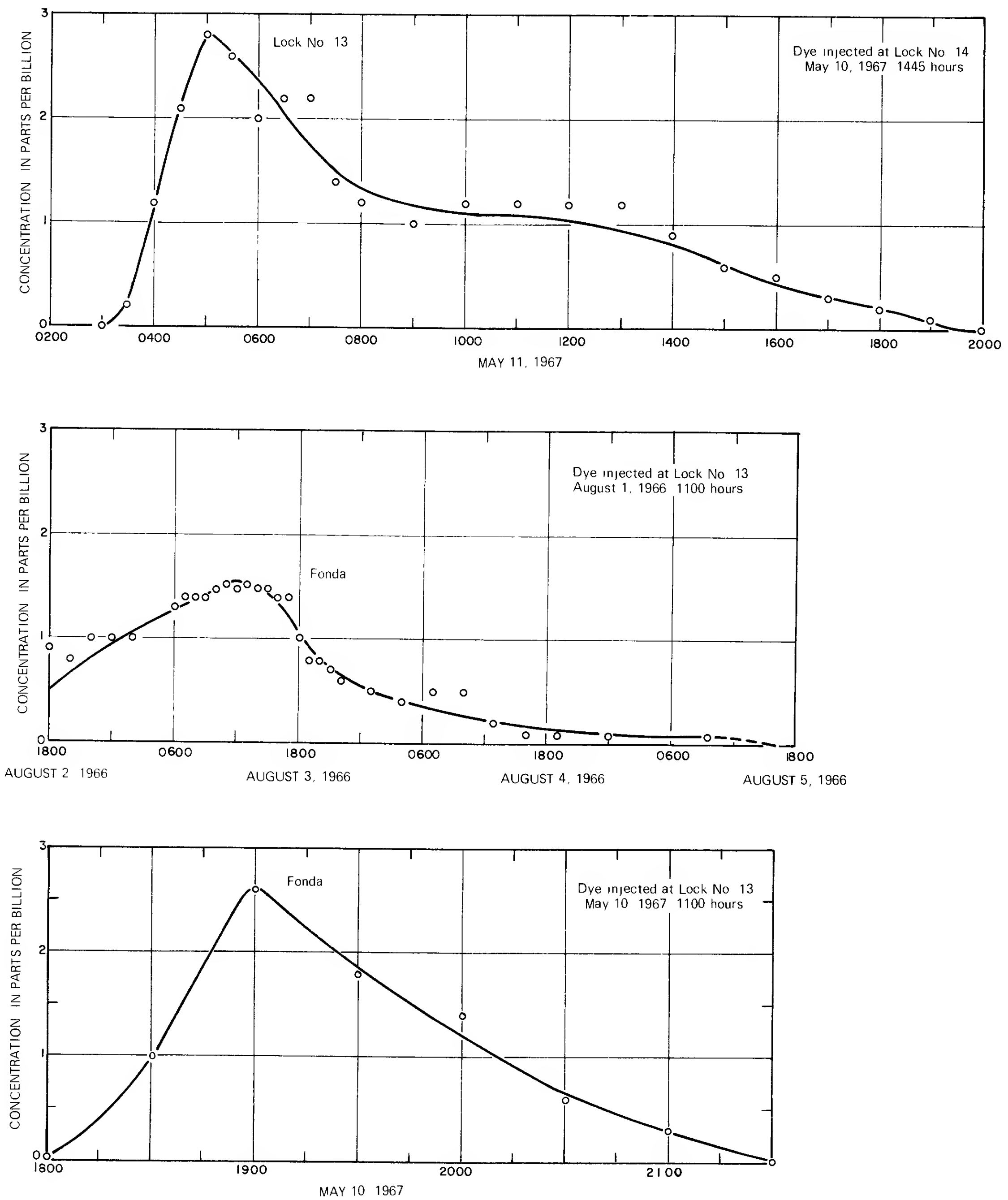

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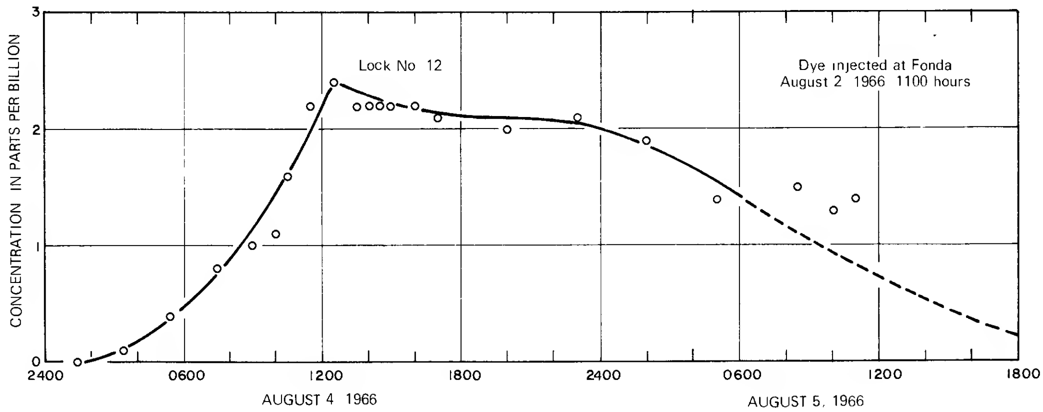

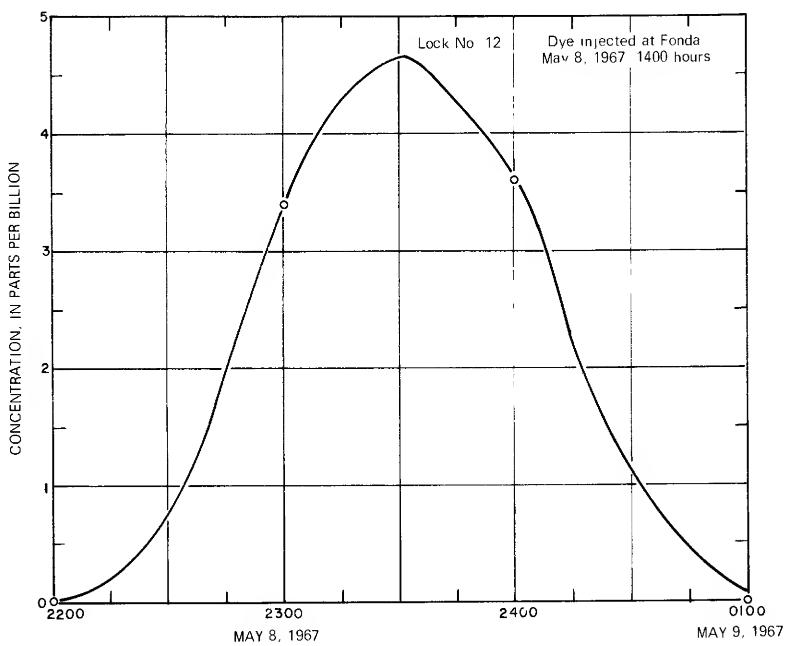

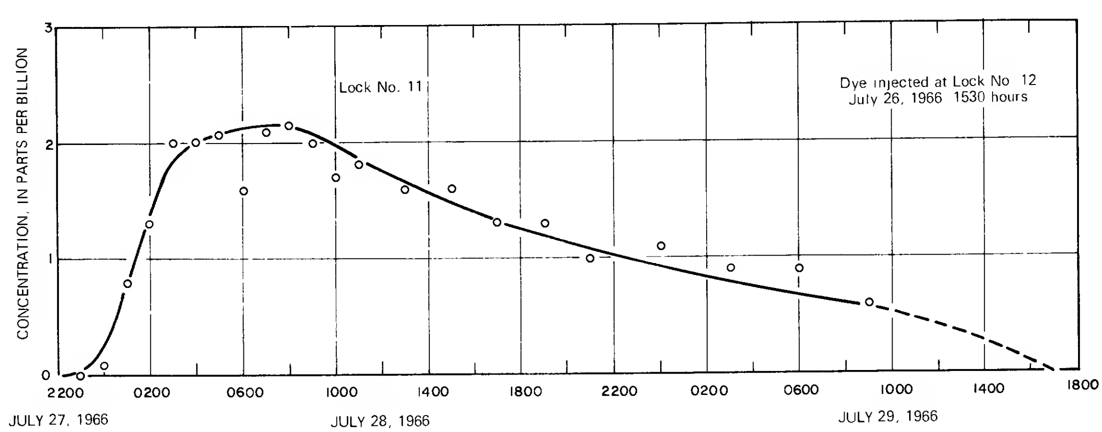

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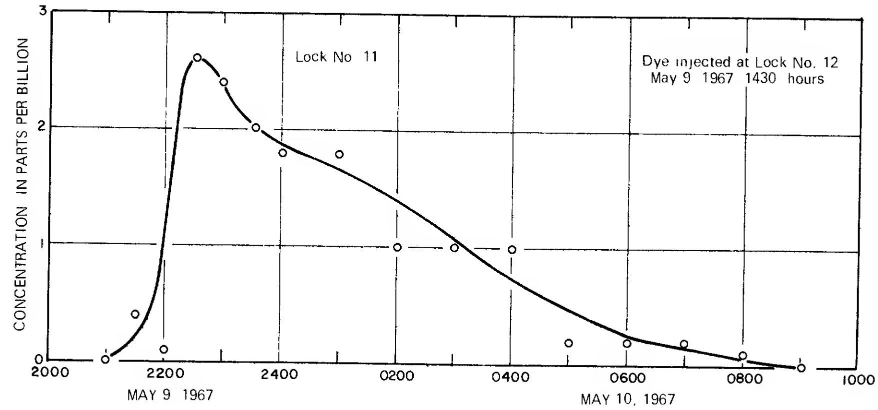

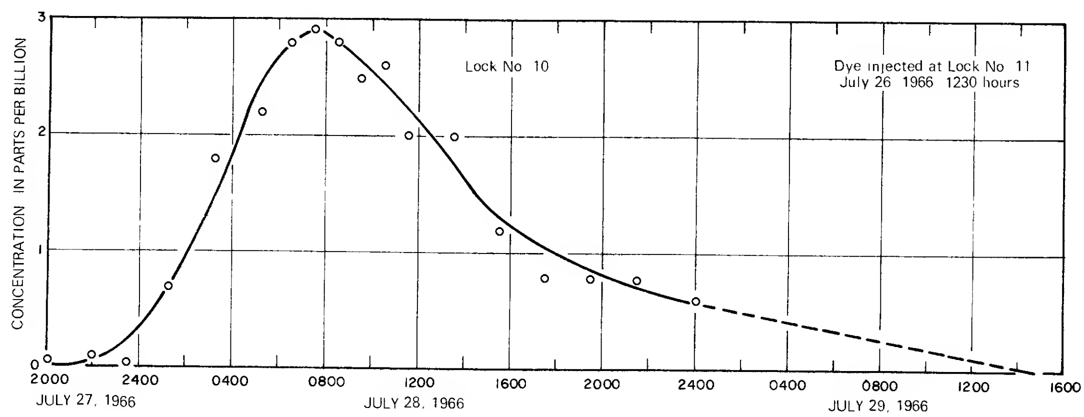

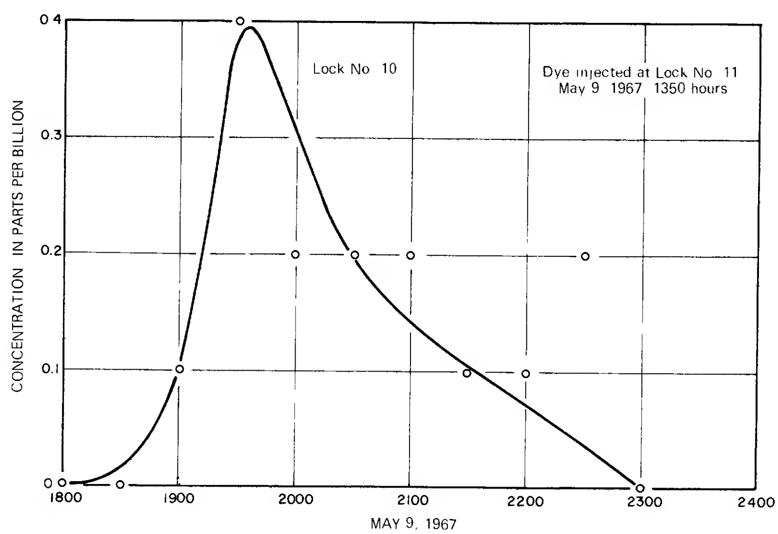

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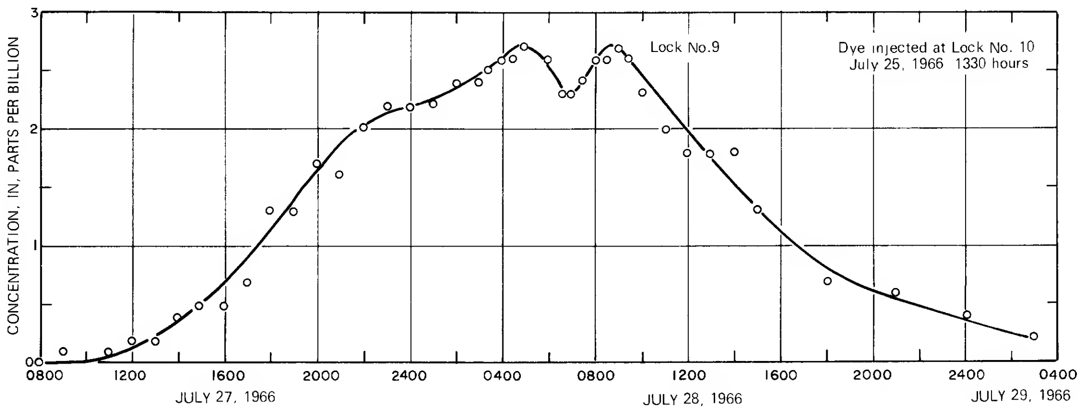

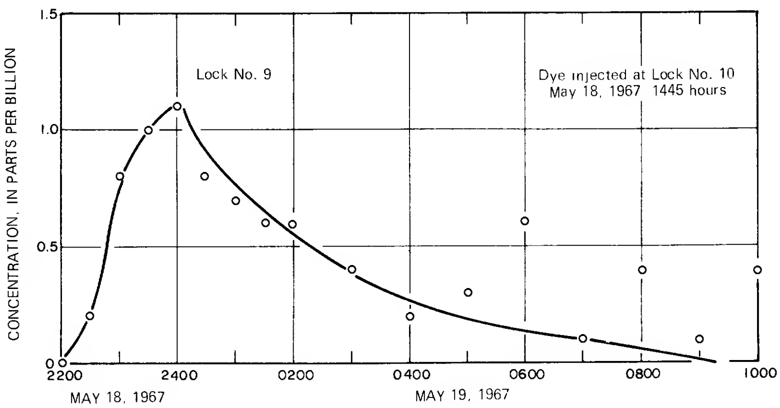

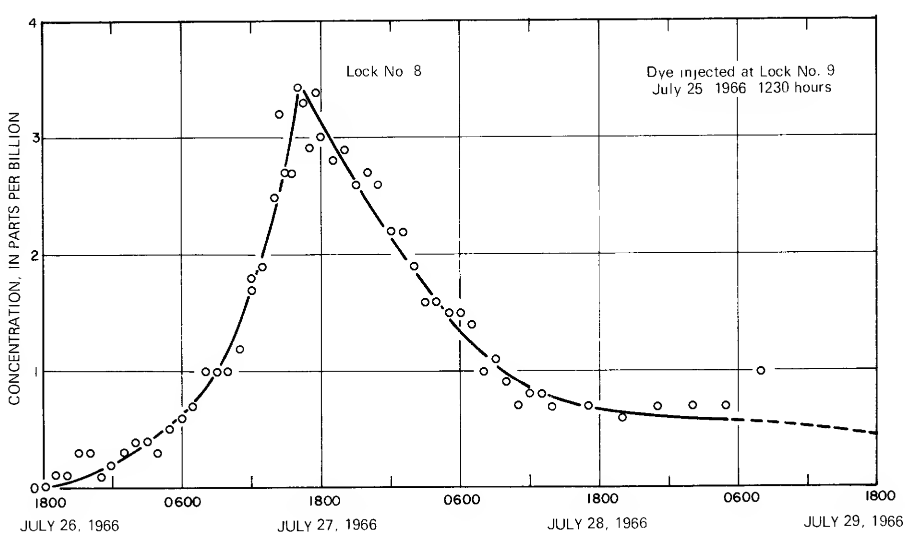

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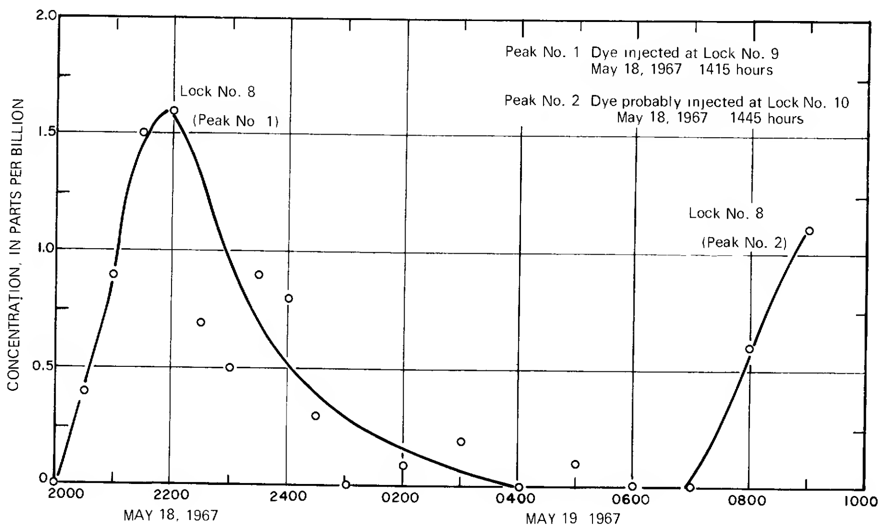

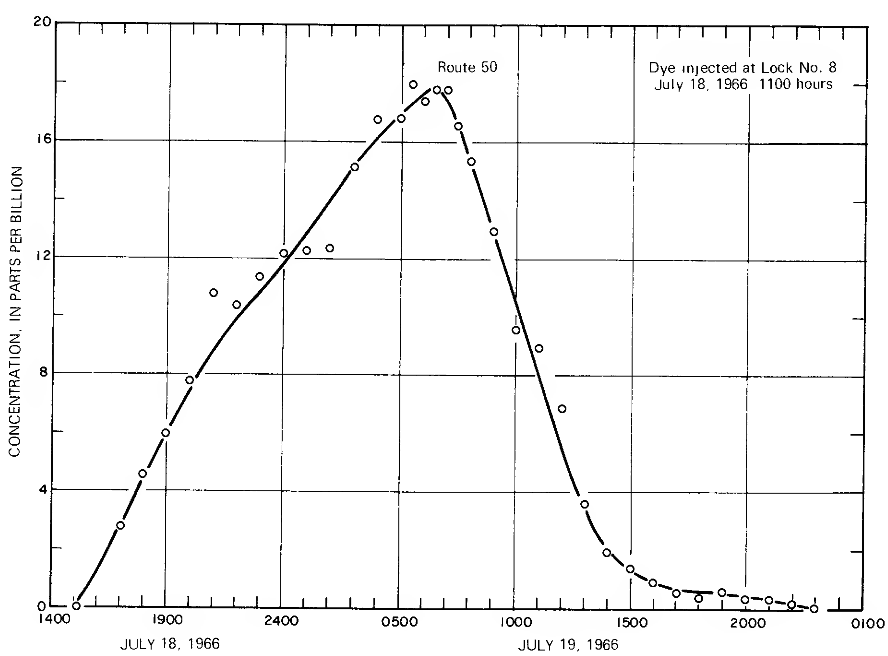

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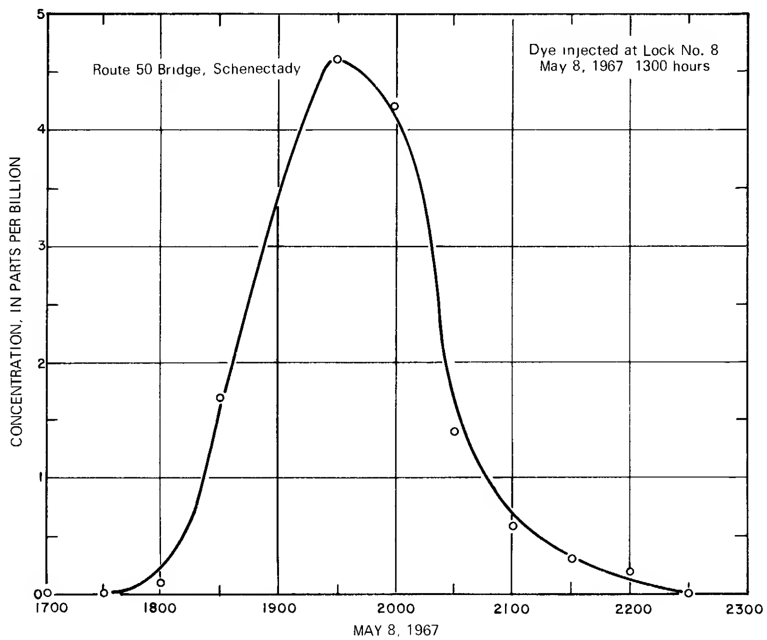

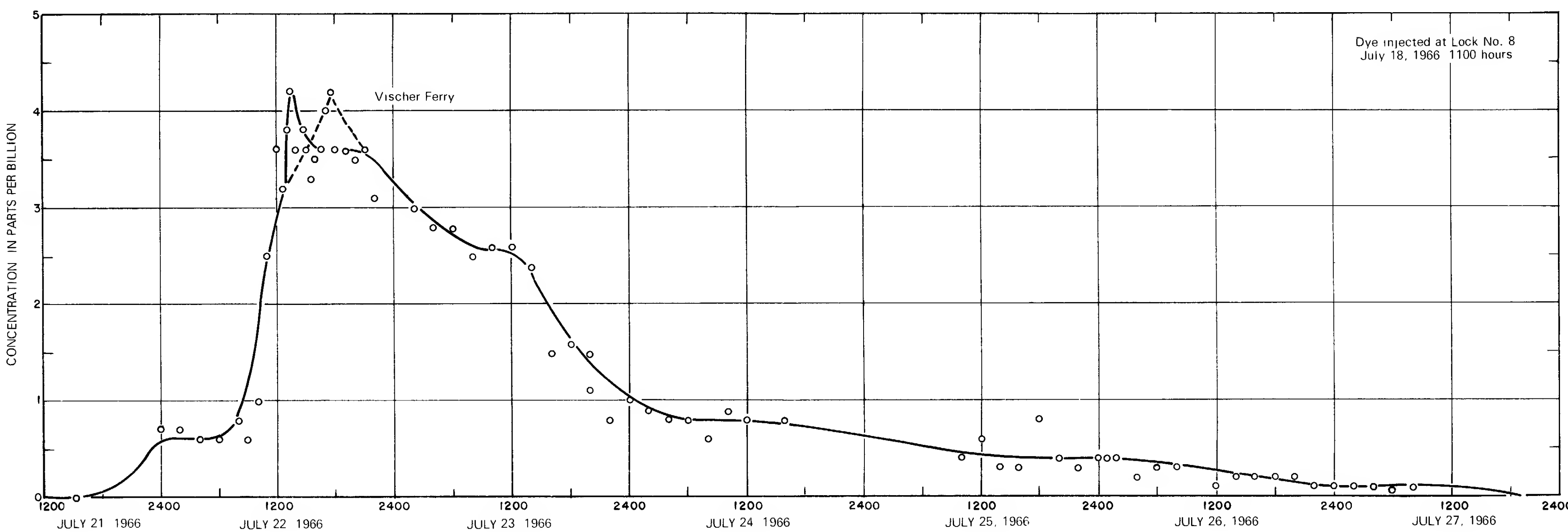

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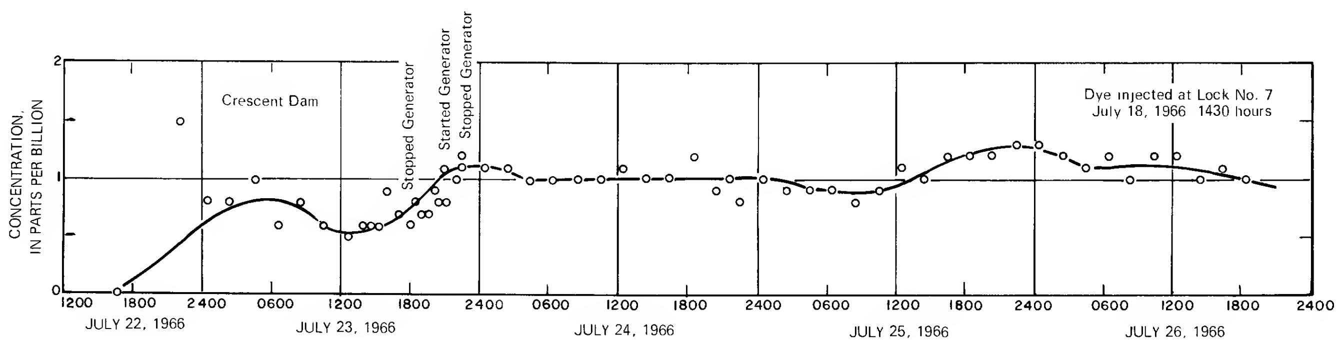
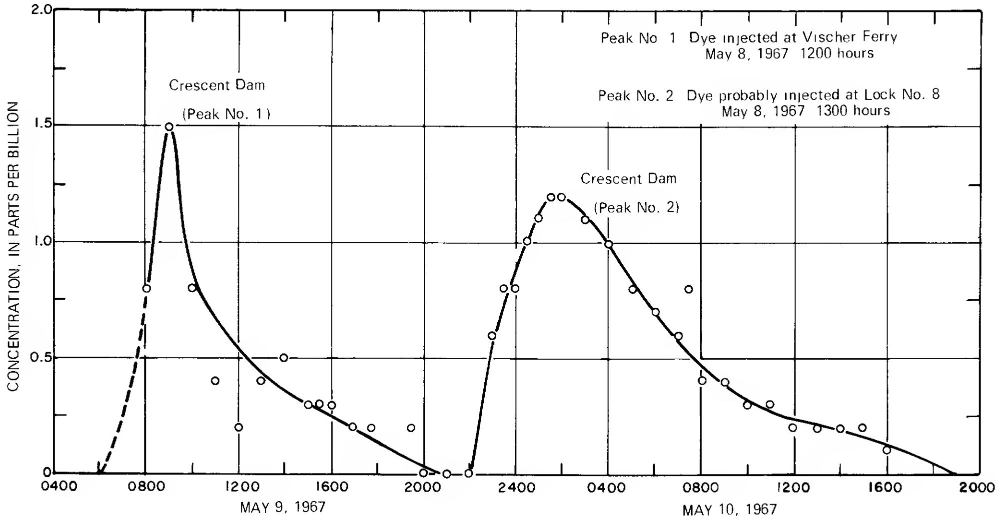
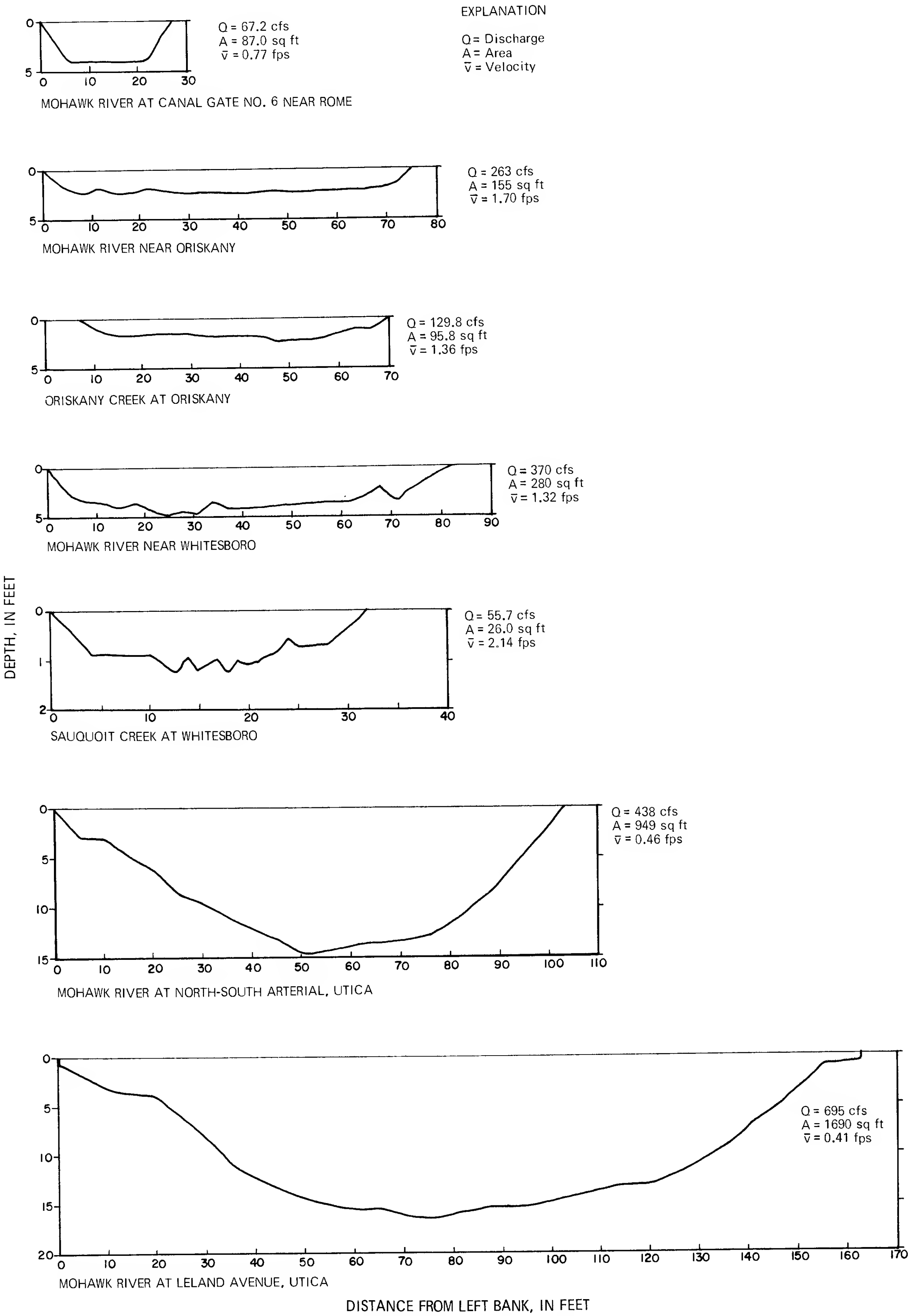
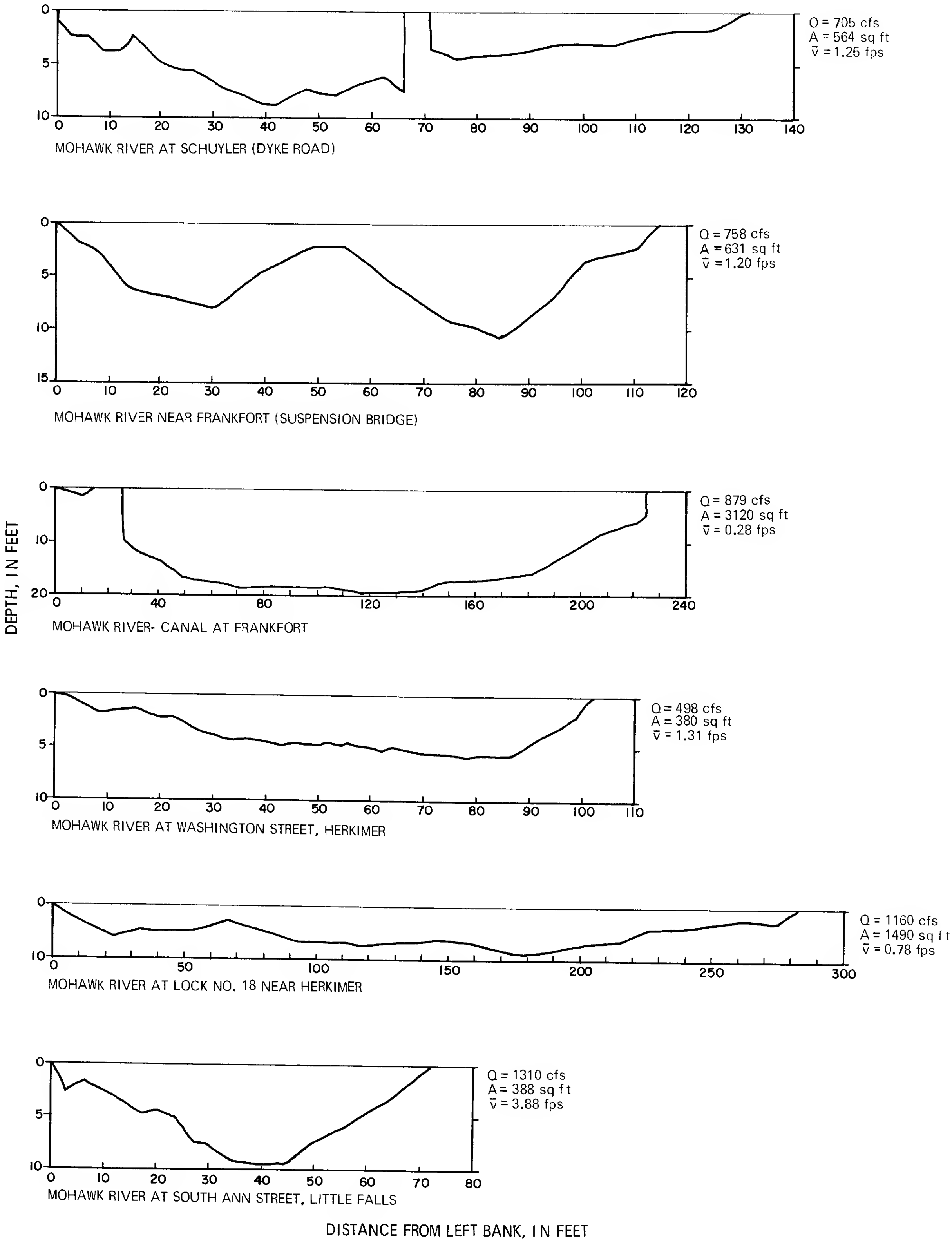




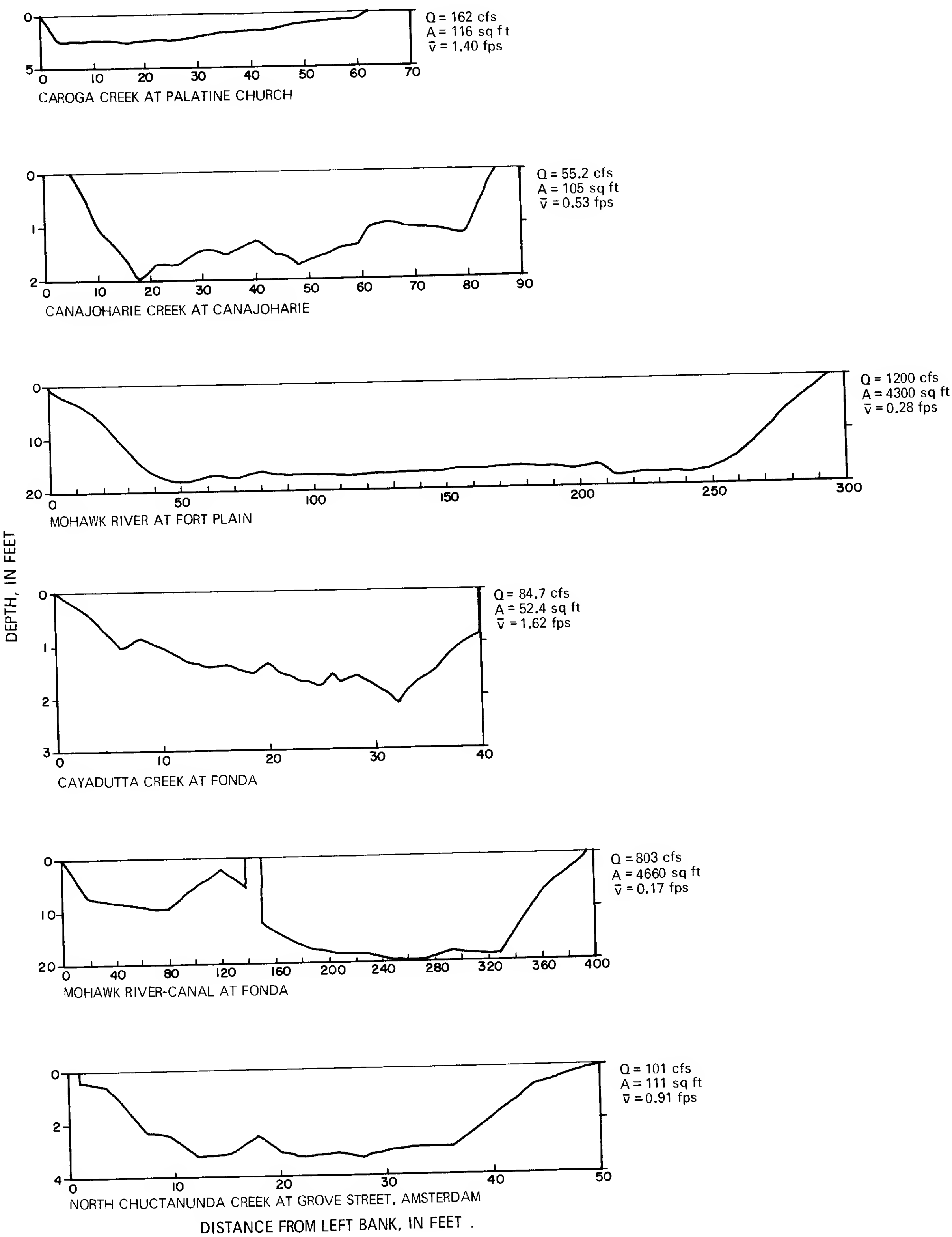
Appendix A.--Time variation and dispersion of dye.



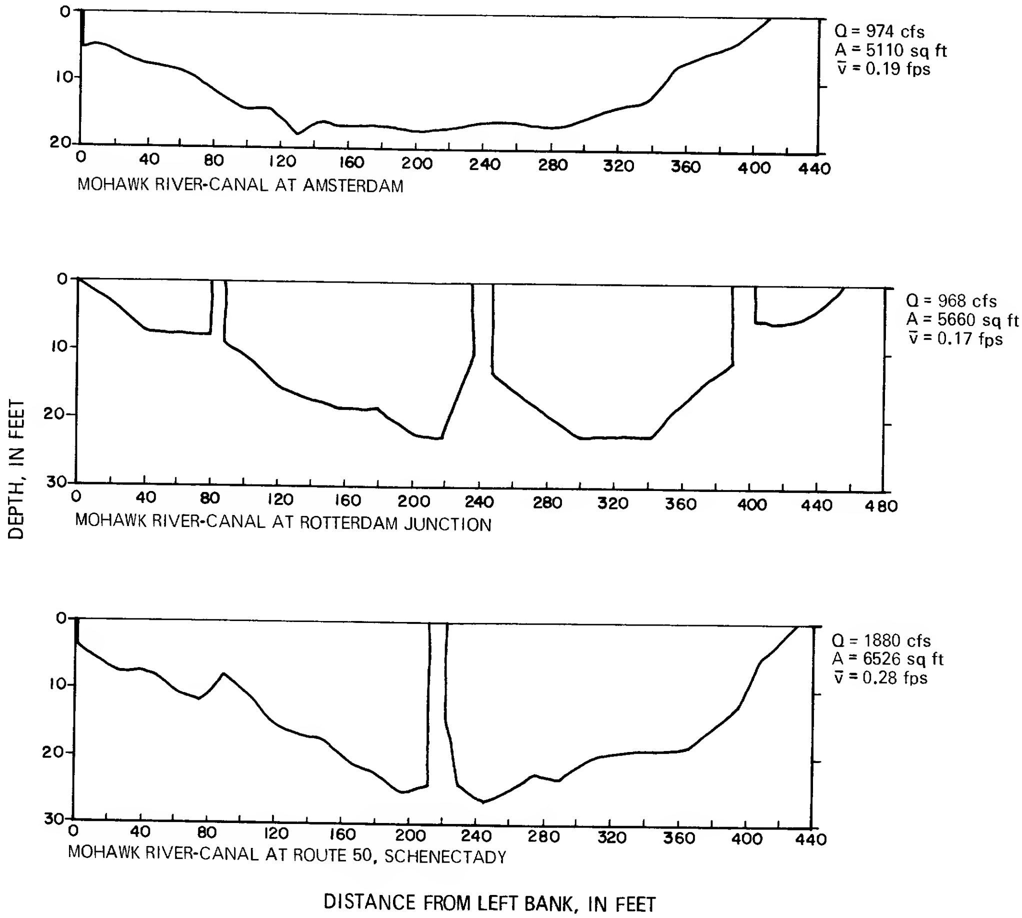
Appendix B.--Cross sections and hydraulic properties.



Appendix B.--Cross sections and hydraulic properties.



Appendix B.--Cross sections and hydraulic properties.



Appendix B.--Cross sections and hydraulic properties.

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